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INSECT SECRETIONS.—II.

By E. A. BUTLER, B.A., B.Sc.

(*Continued from page* 106.)

FOR wax, our second illustration of insect secretions, we must go first of all to the order Hymenoptera, as yielding that variety of animal wax which is best known and most widely used in the Western world. But the production of waxy substances is not confined to hymenopterous insects; for example, while European wax is the produce of the hive bee, the white insect wax of China owes its origin to an entirely different insect, belonging to the order Homoptera, and to that section of it called *Coccidæ*, or scale insects. And, in fact, the power of secreting matter varying from a waxy to a more or less silky consistency is widely diffused throughout this latter order; the makers of these substances, however, do not use them, as bees do their wax, for constructive purposes, but the secretions generally exude in the form of long threads, which remain adherent to the insects as personal appendages of either a protective or ornamental character. The production of waxy and other allied substances is, therefore, associated with two very distinct types of insect life—the hymenopterous, typified by the hive bee, and the homopterous, typified by the scale insects. We will first turn our attention to beeswax.

It was long thought that the honey bee produced its wax from the pollen of flowers, which was supposed to be worked up and kneaded by its feet to the requisite consistency. Nor was this idea unnatural, though erroneous. In the hive were to be found stores of honey and wax; the former it was known that the bees manufactured from the nectar of flowers, and it remained, therefore, to account for the wax in a somewhat similar way. On the bees' legs were seen the masses of pollen they had also gathered, and as the wax seemed more nearly akin to the solid pollen than to the liquid honey, it was an easy supposition that the two were related to one another as raw material and manufactured product. So we find an old writer stating that "from the flowers they gather the wax with the hairs which cover their bodies, and when they return from the fields you may see their hairs full of small particles of wax like dust." This idea prevailed for a long time, and it was not till late in the last century that it became generally recognized that wax was not a gathered substance, but that it originated in the form of scales on the under side of the abdomen of the worker bee.

One of the earliest detailed accounts of the discovery of its true source is contained in a book on bees, called "Melisselogia, or the Female Monarchy," published in 1744. The author, J. Thorley by name, who had for some years devoted himself to bee-keeping, was anxious, as he says, to "find out how or where they brought home their wax," but for some time his efforts were baffled; at length, however, the favourable conjuncture of circumstances occurred, and the problem was solved. This is how he announces his discovery:—"Viewing a hive of bees very busy at labour, I observed one bee among the rest as she fixed upon the alighting place, of an unusual appearance; upon which I seized her directly, before she had time to enter the hive, where, with very sensible pleasure, I found what I had (till then) been in vain searching for. Upon the belly of this bee, within the plaits, were fixed no less than six pieces of solid wax, perfectly white and transparent, like gum; three upon one side and three upon the other, appearing to the eyes equal in bulk and gravity, so that the body of the bee seemed duly poised, and the flight not in the least obstructed by any inequalities. Here have I found it at other times, and once I took away eight pieces together, and I knew that it was wax and nothing else. Will not this pass for demonstration?" This observation showed that wax was not merely pollen worked up—and was, therefore, chiefly valuable as negative evidence—but there was much more to be learnt; for, as Thorley himself says, "how they manufacture the wax, fix it to the hive, and fashion it in so curious a manner into combs and cells, we cannot easily account for."

Thorley's discovery does not seem to have attracted much attention, and in fact apparently remained unknown to the scientific world; for twenty-four years afterwards, Wilhelmi wrote to Bonnet informing him of what was evidently regarded as an interesting novelty, that a Lusatian peasant, who was an ardent bee-keeper, had found wax scales attached to the abdomen of worker bees, and had thus revealed the source of this useful product. A somewhat similar observation had been recorded in Germany even before Thorley's time, so that the truth was independently discovered in several places and at different times. In the *Philosophical Transactions* for 1792, John Hunter gives some very pertinent observations in refutation of the previously accepted notion of the origin of wax from pollen. Thus, while the "farina," as pollen was then called, was often of different colours on the legs of different bees, the newly-made wax was all of one colour; it was gathered with more avidity for old hives, in which the combs were complete, than for those in which the comb was still in course of construction, which could not have been the case if "farina" was the material out of which wax was made.

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Again, at the beginning of a new hive, the bees seldom brought in any spoil on their legs for two or three days, although cells were in course of construction all the time; and lastly, in wet weather, when the bees do not go out, yet much new comb was formed. It thus came to be seen that wax was not to be thought of as a gathered substance, but as a true secretion, and subsequently some careful series of experiments by various observers revealed the fact that it was produced as a result of the digestion of honey. But though honey is the essential ingredient, a little pollen eaten in addition considerably increases the yield. Thus Gundelach showed that it required seventeen pounds of honey alone to produce one pound of wax, while when honey and pollen were both eaten only ten pounds were required for one pound of wax. In Tegetmeier's experiments, from twelve to fifteen pounds of dry sugar were consumed by a hive of bees in producing one pound of wax. These figures serve to show what an enormous amount of the nectar of flowers needs to be collected for wax construction alone, apart from what may be used as food, and sufficiently explain the unflagging industry of working bees.

Let us now follow a bee throughout those operations which result in the secretion of wax. The construction of the comb must be one of the first operations carried out when a swarm takes possession of new quarters, and to meet this demand the worker, before passing out with the swarm, will have taken its fill of honey. This, whether imbibed direct from flowers or from stores already accumulated, must be taken up by means of the complex apparatus to which the name "tongue" is usually given. The whole tongue really consists of several organs fastened together, as will be seen from the accompanying photograph (Plate 1). The central piece, transversely ridged and beset with hairs, is the real tongue, or *ligula*. It is very flexible and extensile, being moved by special muscles situated in the large dark piece at its base (*mentum*.) The pair of organs at the side of the ligula are the labial palpi, each consisting of four joints—two large and two minute. The outermost pair of organs are the maxillæ, or secondary jaws. The whole of this apparatus is used in taking liquid food, and while it is being employed the biting jaws, or mandibles, which are not shown in the photograph, cannot be used, though they have to be called into requisition when anything solid has to be bitten, in which case the "tongue" must be folded back out of the way. The maxillæ and labial palpi close around the ligula and form a channel, within which it can move up and down so as to assist the passage of liquid towards the mouth.

There has been a great deal of controversy as to the exact method by which this apparatus secures the passage of nectar to the mouth, which, it must be remembered, is situated a considerable distance from the tip of the fully extended tongue. As the whole thing is on a small scale, and therefore needs close watching under a lens, and as the movement of the liquid takes place within a closed space, the evidence is mainly circumstantial, and it is hardly surprising that different interpretations have been put upon it. At the extreme tip of the tongue is a rounded part, less thickly supplied with fine hairs and called the spoon. When honey is to be taken up, the bee extends its tongue, and bending the tip under, applies the concave surface of the spoon and part of the hairy tongue to the liquid, and moves it quickly backwards and forwards. In consequence the sticky liquid adheres and spreads amongst the hairs, the immense number of which is shown in photograph No. 2; the withdrawal of the ligula carries the nectar into the space enclosed between the maxillæ and palpi, up which it is drawn partly, no doubt, by the capillarity of the small grooves and interstices amongst which it finds itself, and partly by suction. The syrup taken in this way is swallowed into a temporary receptacle or crop at the base of the gullet, which is often called the honey stomach or honey bag. Between this and the true stomach lies a small apparatus called the stomach mouth, which, by opening and closing at intervals, acts as a regulator to the passage of the honey into the true digestive cavity.

The bee whose fortunes we are following having swallowed honey till its crop is completely distended, passes out with the swarm, and partakes in the general movements until the whole tribe is safely housed. Now will come the business of wax secreting, and for this a restful position and a temperature of from 30° to 37° C. is necessary. The latter condition is attained by the bees clustering together, but the former is achieved in a very curious manner. A bee takes up its position at the highest part of the hive, hanging from the roof by her fore legs; another then clings to this one's hind legs by her fore legs, the pair of hooks with which each is, as usual, provided enabling this to be done with ease. Several others follow suit till a whole chain is produced, all depending directly or indirectly upon the fixity of hold of the originator of the chain. Two chains hanging near together effect a junction by the end bees of each clinging to one another's hind legs, and so festoons of living beings are made, hanging about in all directions. In this way all the workers who are to secrete wax hang themselves up and remain in festoons for some twenty-four hours. Meanwhile the honey has been gradually passed into the true stomach and has been digested. In consequence of this, certain cells lying just underneath the skin of the under surface of the abdominal segments begin to form within themselves a liquid substance, which in due course passes out through the skin by means of a network of minute polygonal openings. Thus a liquid begins to collect on certain white, transparent and slightly depressed portions of four of the abdominal segments, one on each side of each segment; these are arched over by the free edges of the preceding segments, which mould the liquid into a thin plate, and this soon hardens by exposure to the air, appearing as yellowish-white scales. The flattened depressions in which they lie are called wax-pockets (Fig. 4), and are found only in the workers.

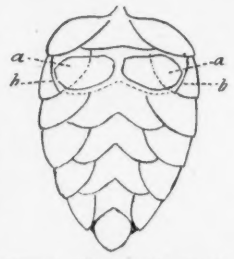
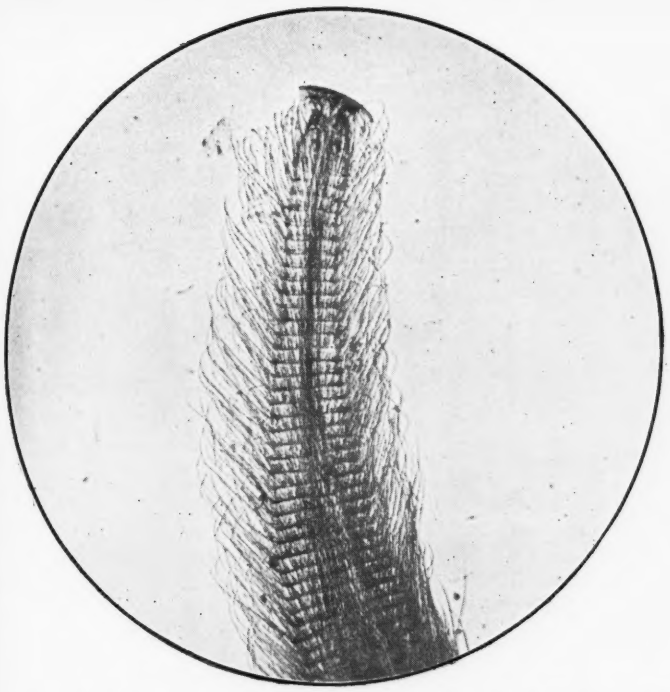
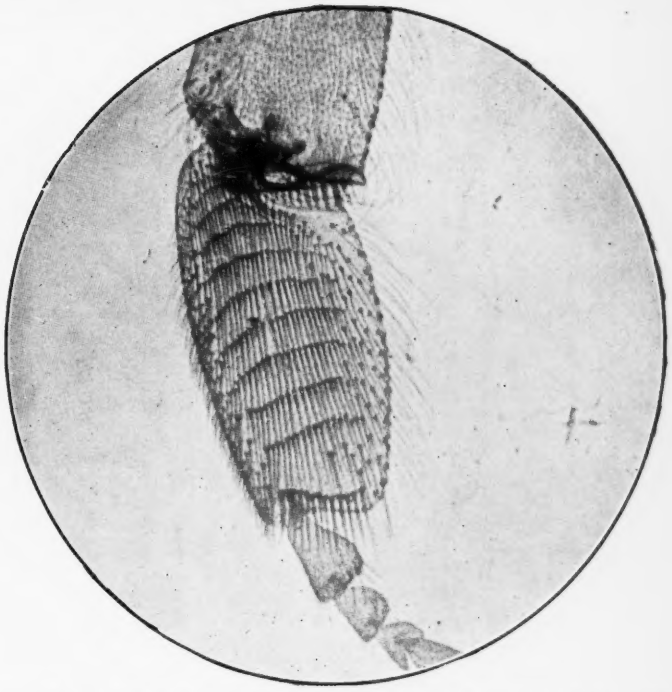


FIG. 4.—Under side of abdomen of Worker Bee. Part of the plates of the second segment has been removed to show (*a*) wax-pockets, (*b*) cut edge of plates. The dotted lines show the position of the removed parts. Magnified five diameters.

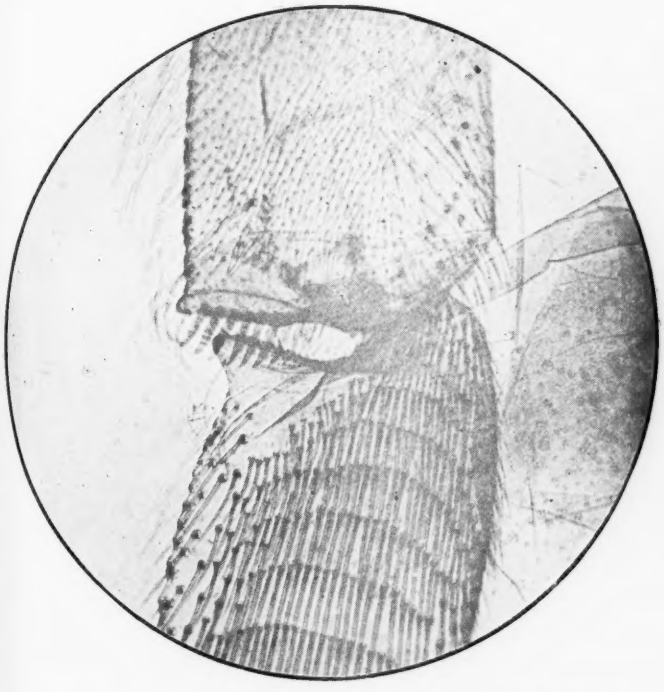
The substance thus secreted and collected in the form of four pairs of thin scales under the abdomen, though containing the essential constituent of wax, is not yet in a proper state to be used for building purposes. It has to be chewed up and mixed with saliva. Our bee, therefore, when its wax scales are all ready, extricates itself from the festoon and goes to the place where building operations are to be commenced. In order to understand what follows, we must look for a moment at the bee's hind legs. Here we find nothing remarkable till we reach the end of the broad tibia or shank. At this point, if we were dealing with any other kind of British bee, we should find on the *inner* side a pair of stout, sharp-pointed spurs, as may be seen in Fig. 5, showing the hind leg of a humble bee; but in the hive bee these are absent, as photograph No. 3



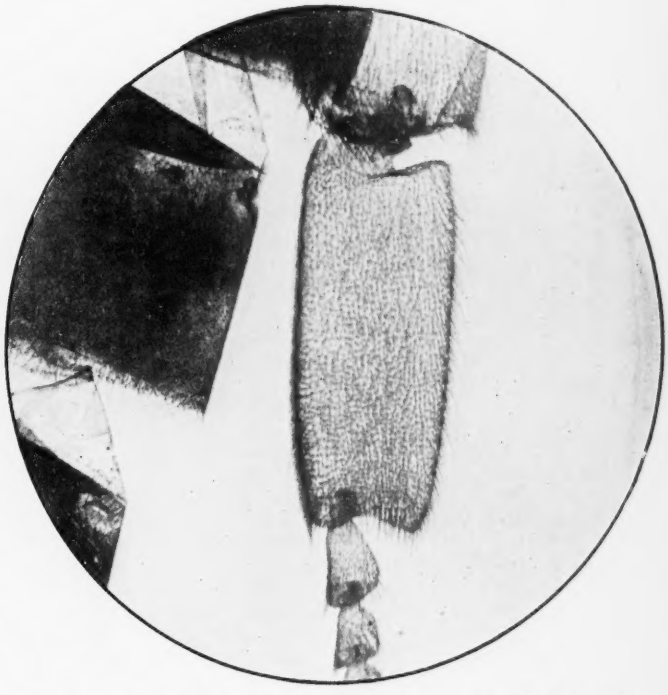
No. 2.—Tip of Worker Bee's Tongue (*ligula*), showing its ridged appearance and thick clothing of hairs.



No. 3.—Hind Foot of Worker Bee, showing the ridged *planta*, with its auricle and comb.



No. 4.—Junction of tibia and planta on Worker Bee's Hind Leg, more highly magnified, showing auricle and comb.



No. 5.—Hind Foot of Queen Bee, showing absence of auricle and comb.

The above are reproduced from Photographs taken by Dr. E. J. Spitta.

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shows, and we find instead, on the *outer* side, an apparatus which can be used as pincers. The first joint of the foot proper, or *planta*, is very broad, as much so as the tibia itself, and on the inner face it is furnished with rows of hairs which give it a ridged appearance (see photograph No. 3); outside it is quite smooth. Now the outer and upper corner of this planta is excavated and broadened, so that a spoon-shaped depression is formed, which faces the outer angle of the tibia and is called the "auricle." The edge of the tibia opposite the auricle bears a row of stiff bristles, called collectively the "pecten" or comb (see photographs 3 and 4). This apparatus of auricle and comb is found only on the hind legs of the worker bees, as will be seen by comparing the photographs of the worker's (3) and queen's (5) feet. By these two structures the waxen scales are seized as they project from the abdomen and pulled off; they are then passed on to the front pair of legs, by which they are held up to the jaws to be masticated and mixed with saliva. As a consequence of this treatment the wax becomes ductile and plastic, and can easily be moulded and shaved down or excavated to the required shape. Beyond this point the scope of our paper does not permit us to follow its history.

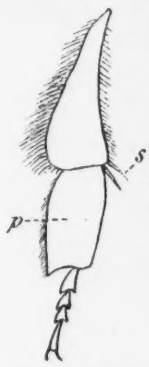

FIG. 5.—Hind leg of Humble Bee. *p*, planta; *s*, spurs.

When freshly built into combs, wax is generally of a pale yellow colour, but other shades are met with, and variations of this kind are due to the pollen which the bees have consumed in addition to the honey that forms the basis of the secretion. White pollen, such as that of the heather, has the effect of whitening the wax, while dark orange pollen intensifies its natural yellowness.

The value of beeswax to man arises from its plasticity and combustibility. Its uses are manifold, and many of them may be traced back to a very remote antiquity. The readiness with which wax receives impressions and the accuracy with which, owing to its lack of elasticity, it retains them, early led to its adoption as the most suitable material for coating writing tablets, and the same property made it a valuable adjunct of the law courts for use either in the form of tablets or seals. In ancient times it was also employed in the arts, as a medium for the mixing of painters' colours. Pliny has left an account of the method of its preparation for this purpose. Ordinary beeswax was boiled three times in sea-water with a small quantity of nitre, and by this means it was purified and bleached. After careful drying it was fit for mixing with all kinds of colours, and was then called Punic wax.

When we try to form some idea of the quantity of wax that must have been annually consumed in the ancient world for such purposes as those mentioned above, as well as for the many other uses to which it was put, it becomes evident that we have in wax secretion an excellent illustration of the wonderfully great total that can be reached by accumulated littles. For, though individually each wax scale as produced by the bees is a minute object no larger than about one-fifteenth of an inch long by about two-thirds as much in breadth, the gross amount produced season by season to supply the needs of the civilized world must have been very large, and must have necessitated the formation of millions upon millions of wax scales. And although some of its ancient uses have become obsolete, others have taken their place, and wax still remains to man a valuable product of insect agency, and the labours of the bees are still of the utmost importance not only in the economy of Nature, but also in the service of man. If we try to estimate the enormous quantity annually consumed at the present day, in the form of wax candles, in those countries in which the burning of candles forms an essential part of all ecclesiastical observances, and if we remember the great disproportion that exists between the quantity of honey consumed and that of wax secreted—the ratio being sometimes as great as seventeen or eighteen to one, as already mentioned—we see that for this purpose alone there must be vast multitudes of bees hard at work day after day, pilfering from the flowers of the hillsides, gardens, and meadows of Europe that nectar which is to serve as the raw material for so huge an amount of secreted wax. And when we add to this the amount of honey that is not devoured for wax secretion, but stored for future use, and brought into the market before its conversion into wax, we need no further evidence of the incredible activity and industry which these small insects display, and which have been the admiration of the world from time immemorial. Their eagerness for gathering honey indeed is so great that they become reckless and infatuated in its pursuit. The following scene, described by Dr. Langstroth, will illustrate this:—"No one can understand the extent of their infatuation until he has seen a confectioner's shop assailed by myriads of hungry bees. I have seen thousands strained out from the syrup in which they had perished; thousands more alighting even upon the boiling sweets; the floor covered, and windows darkened with bees, some crawling, others flying, and others still so completely besmeared as to be able neither to crawl nor fly—not one in ten able to carry home its ill-gotten spoils, and yet the air filled with new hosts of thoughtless comers."

The secretion of wax is not confined to the hive bee amongst the Hymenoptera; the humble bees also have the power of producing a similar substance, although in very inferior degree, since no definite comb is made, and the wax is used only to strengthen the cocoons, and stop up cracks and crevices in the roof. They differ from the hive bee also in not being provided with wax-pockets. The economy of these *Bombi* is much less elaborate than that of the hive bee; they have, as it were, advanced less far along the path of civilization, and are therefore satisfied with more primitive and less refined arrangements, especially in the accommodation of their larvæ. Thus, while the hive bee provides each of its grubs with a separate cell in which to live and undergo its transformations, the *Bombi* simply deposit their eggs here and there on a shapeless heap of pollen, which constitutes the stored provision of the establishment, and each larva as it hatches begins to eat from the store immediately around it, thus excavating a hollow which serves it as a cell. When the larva is full fed, this is lined with silk, and its walls may then be strengthened with wax by the old bees.

(To be continued.)

THE LUMINIFEROUS ETHER.

By J. J. STEWART, B.A.Cantab., B.Sc.Lond.

(*Continued from page* 112.)

IT becomes an interesting question whether moving bodies, such as the earth in its course through space, carry the ether with them or pass through it without causing any motion of the ether in their direction. Do the matter molecules drag the ether along with them or not? Dr. Young, to whom the advance of the undulatory theory of light owed so much

at the beginning of this century, supposed that the motion of the ether was not affected by the passage of gross matter through it, but that the ether passed through solid masses such as the earth or the planets freely like the wind through a grove of trees, or water through a wide-spaced net dragged through it. The earth, according to him, moved on its path, but the ether within it and around it remained fixed in space. Experiments have been made to test this question of the relative motion of the ether, but it still remains unsettled. Some experiments seem to point to one conclusion, some to the other.

The phenomenon of aberration, which consists in a periodic displacement of the position of a star as seen from the earth, the period of the displacement being a year, is usually explained as due to the composition of the velocity of light with the velocity of the earth in its orbit. Owing to aberration, in order to observe a star in the direction A C or B D a telescope must be pointed in the direction A D, if in the figure A C represents the velocity of light and A B the velocity of the earth. The apparent position of a star is always in front of its true position. A ray entering the telescope tube at D will travel with the velocity of light and reach the other end of the telescope while this latter has travelled with the earth from A to B, so that the direction of the ray in the telescope is along D A. Thus aberration is satisfactorily explained. But if this is the true explanation, the amount of aberration must depend on the medium which is contained in the tube if the ether is not affected by the moving matter, for the velocity of the light considered is its velocity through the medium filling the telescope.

The effect of filling the telescope tube with different substances has been tried by Sir G. B. Airy at Greenwich, and he found that the aberration was the same whether the tube contained air or water. Now, in the wave theory the index of refraction of a substance is the ratio of the velocity of light in vacuum to its velocity in the substance, and as the index of refraction of water is one and one-third, the velocity of light in air is four-thirds of its velocity in water, and the aberration with a telescope containing water should be four-thirds of its value under ordinary conditions, on the supposition that ether is not dragged along with moving matter.

To account for the fact that the aberration remains constant it has been suggested that moving matter carries the ether, or a portion of it, along with it. M. Fizeau has made experiments to investigate how far the velocity of light is affected by the motion of the medium, *i.e.*, the matter through which it passes. If we imagine a luminous object and an observer to be fixed in position relatively to the ether, then if the medium intervening is moving towards the observer and it carries the ether with it, the velocity of the waves towards the observer will be increased, but if the ether does not move with the matter of the medium the velocity of light will not be affected by the motion.

In Fizeau's experiment a pencil of rays from a narrow slit was sent through two parallel tubes containing water and reflected back again to the observer. The water was made to flow through the tubes, in an opposite direction in each, with a velocity of over twenty feet per second; and one half of the beam of light went through one of the tubes travelling in the direction of the flow of water and back through the other still in the direction of flow, while the other half of the light went in a direction against the flow of the water, entering through the second tube and returning by the first. The rays of light which had traversed similar paths were brought to a focus by a lens, and if the velocities of the rays were affected by the moving water they would be affected in opposite directions, and thus a difference in the time of transit would be caused and a phase difference produced which should give rise to interference fringes. By altering the direction of the stream of water in the tubes displacement of the fringes should take place if the ether is dragged along by the water, and this is what Fizeau found was the case. The fringes were displaced towards the right or towards the left of the observer according as, in the tube placed at the right of the observer, the movement of the water was towards the observer or in the opposite direction.

Interference consists in the crest of one wave coinciding with the trough of another and thus producing an absence of resultant effect, or in two crests coinciding and thus producing heightening of effect. When a beam of light is split into two portions which are made to traverse slightly differing paths, and these two portions are made to meet again and overlap, in some places crests may fall on troughs and cause there an absence of light, and thus lines of darkness or interference fringes may be produced. This is the principle involved in Fizeau's experiment, and by measuring the amount of shifting of the interference bands he obtained a measure of the change produced in the velocity of the light by the motion of the medium traversed. From his experiment he concluded that Fresnel's theory was correct, according to which the ether is partly dragged along by the surrounding matter in proportion to its refractive index, so that the velocity of the matter need not be taken into account, or added to or subtracted from the velocity of the light, but that the excess of the ether within the medium over that outside is alone carried along. According to Fresnel's theory, if V is the velocity of light, and v the velocity in a transparent medium, and the index of refraction of the medium is n, then the velocity of light in the direction of the motion of the medium will be $V + \frac{n^2 - 1}{n^2} v$. This closely agrees with Fizeau's result.

Messrs. Michelson and Morley, in America, a few years ago made experiments to test if there was any relative motion between the luminiferous ether and the earth, and the conclusion they came to was that if there was any it was small—that is, that the ether is carried along with the earth on its course through space. This result is in contradiction to the ordinarily accepted explanation of aberration. The nature of the experiment consisted in sending light along two paths, one in the direction of the earth's motion, and the other at right angles to it, and by reflection causing the rays to fall on the same point, and produce interference owing to the difference in path. By sending the ray which went in the direction parallel to that of the earth's motion first with this motion and then against it, displacement of the interference fringes should take place if there is relative motion between the earth and the ether, and the amount of the displacement which would occur can be calculated. Mr. Michelson found that the displacement was probably less than the fortieth part of what it would have been if the ether was at rest and the earth moved relatively to it, and certainly less than the twentieth of this value. The observations were made with great accuracy, and Michelson reckoned that he could detect an alteration of one part in four thousand millions, if it existed. This is equivalent to detecting an error of less than one-thousandth of an inch in fifty miles, and

the experiments point to the conclusion that the earth carries the ether with it.

Prof. O. J. Lodge has recently been making experiments to find if he can detect any motion of the ether caused by that of neighbouring matter. He uses two steel discs about a yard in diameter, clamped together with a space of one inch between ; these are made to spin round very fast. Then a parallel beam of light is split into two by a semi-transparent mirror, *i.e.*, a piece of glass silvered so thinly that it lets half the light pass through, and reflects the other half, and the two portions of this divided beam are sent by successive reflections round and round the space between the discs, in opposite directions. After traversing thus a distance of from twenty to forty feet, they are finally made to meet and enter a telescope. In general, the lengths of the paths of the two portions of the beam differ very slightly, and thus they interfere. It is observed whether the motion of the discs is able to cause displacement of the interference bands, but Prof. Lodge could detect no true shift of the bands. He says : "Of real reversible shift, due to motion of the ether, I see nothing. I do not believe the ether moves. It does not move at a five-hundredth part of the speed of the steel discs." Circular saws, railway trains, &c., he thus concludes, do not carry the ether with them ; their motion does not seem to disturb it at all. The presumption is that the same is true of the motion of the earth. Prof. Lodge thinks that "if moving matter disturbs ether in its neighbourhood at all, it does so by some minute action comparable in amount, perhaps, to gravitation, and possibly by means of the same property as that to which gravitation is due—not by anything that can fairly be likened to ethereal viscosity."

Prof. Lodge has recently been able to increase the velocity of his discs to three thousand revolutions per minute, but even with this rapid rotation nothing which can be attributed to a drag of the ether has been detected.

On the other hand, Mr. Michelson concludes from his experiments that the relative velocity of the earth and the ether is probably less than a sixth of the earth's orbital velocity, and certainly less than one-fourth. Thus the question of the connection of the ether with gross matter, and the relation of its motion to that of the earth and the heavenly bodies, is still by no means settled.

Not only has the luminiferous ether been applied to account for the propagation of waves of light, and for the phenomena of electrification by supposing this to be due to stresses set up in it, but Lord Kelvin has suggested that the ultimate atoms of matter may consist of vortices or whirlpools in the ether. He has pointed out that by means of motion alone, in a fluid destitute of elasticity, a virtual elasticity may be produced. It is well known that a quasi-rigidity may be conferred on a limp chain by causing it to rotate rapidly. If when rapidly revolving the chain be struck, a permanent kink or bend is made in it which retains its form while the rotatory motion lasts. Moreover, two smoke rings when they collide rebound from each other as if they were elastic, this appearance of elasticity being conferred on them by their motion. Thus Lord Kelvin's hypothesis in his kinetic theory of matter is that atoms are not hard and solid, but that they consist of rotatory rings or whirls in an incompressible frictionless fluid which is perfect and homogeneous, this fluid being the ether, and differences in the elementary atoms are due to differences in the character and behaviour of these vortices, which may be linked together in various ways. A serious objection to the kinetic theory of gases, by which they are represented as consisting of hard solid spheres flying about and colliding with each other, has been pointed out by Lord Kelvin. It is that the effect of the collisions must be to gradually convert the energy of translation into shriller and shriller vibrations of the molecule, and that finally all the translational energy will be changed into this form. Thus on the elastic solid hypothesis of the atom the result is not much different from what it would be if there was imperfect elasticity. If there is no tendency of this sort in the case of the vortex atoms, a serious difficulty would be got over. Such atoms, moreover, would possess the properties of unchangeability and indivisibility ; they cannot be cut, for they would simply wriggle away from the cutting instrument. They are capable of vibrations, and mutual action at a distance can be explained by continuous action through the intervening ether.

THE GENESIS OF FLOWERS.

By the Rev. ALEX. S. WILSON, M.A., B.Sc.

THE flowers most generally known are brightly coloured blossoms adapted for insect fertilization ; only these require to attract insects, which is the end served by the perfume and conspicuous colouring. Very many plants, however, bear blossoms so small and obscurely coloured that they are commonly either entirely overlooked or not reckoned as flowers at all. The wind-fertilized flowers of the dock and nettle have no occasion for the services of insects, and are destitute of honey, odour, and brilliant petals. Still more insignificant in appearance are the little self-fertilizing cleistogamic flowers which, towards the end of the season, are produced on the dog-violet. All three kinds possess stamens and pistils, and are therefore recognized as flowers by botanists. Besides stamens and pistils, which are the essential organs of a flower, petals and sepals are usually present. The petals collectively compose the corolla, the sepals the calyx ; both together being spoken of as the floral envelopes or perianth. Occasionally, as in the ash, the flower is reduced to its essential organs, the floral envelopes being absent. Plants bearing flowers, whether with or without floral envelopes, are designated phanerogams or flowering plants ; they constitute the highest division of the vegetable kingdom. Ferns and mosses, again, are examples of the cryptogamic or flowerless class ; they never bear flowers or seeds, but are propagated by minute reproductive bodies termed spores. This class is divided into thallophytes and vascular cryptogams. The organization of a thallophyte is very simple ; the plant-body of a fungus or sea-weed, for example, consists entirely of similar cells, and externally shows no distinction into root, stem, and leaf. The structure of a vascular cryptogam, such as a club moss, horsetail, or fern, is more complicated ; both cells and vessels enter into the composition of its tissues, and externally the distinction of stem and leaf is apparent. Phanerogams also admit of a twofold division into gymnosperms and angiosperms ; conifers, cycads and yews are gymnospermous, having naked seeds, exposed either on the ends of branches or on the surface of open scales. All ordinary flowering plants produce their seeds in the interior of a closed ovary, as the lower part of the pistil is called ; from this peculiarity they are termed angiosperms.

Only the remains of thallophytes have hitherto been discovered in the oldest Palæozoic rocks. Vascular cryptogams appear in the Silurian strata, attain their maximum in the Carboniferous age, and in succeeding formations are gradually displaced by gymnosperms. The

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latter occur as early as the Devonian period, but the prevailing type of vegetation down to the close of Palæozoic time continued to be cryptogamic. Angiosperms possibly existed as far back as Permian times, but it is only in the chalk that their remains begin to be abundant; the vast majority of Mesozoic plants seem to have belonged to the gymnospermous type. Plants with conspicuous flowers only date from Tertiary times; they increase in number and importance as we approach the present day.

Although the plants entombed in the rocks are only an inconsiderable fraction of the numbers that formerly existed, the general succession just indicated is fully made out, and as the palæontological evidence accumulates it tends more and more to establish the view that coloured blossoms are, geologically speaking, of comparatively recent origin. The vegetation of the earlier geological epochs was marked by a singular uniformity of character; not only were there fewer species than now, and these widely distributed over the globe, but the monotonous green of Palæozoic and Mesozoic forests was unrelieved by gay blossoms such as adorn our fields and orchards. We are indebted to geology for another important fact; fossil plants occur which have no near relatives in the existing flora. Intermediate forms which cannot properly be classified with any living family are met with; in others the characters of several modern groups are blended. Although these generalized forms rather upset our systems of classification, they have an important bearing on the origin of living plants. But what a different aspect, when the coal plants were growing in primeval luxuriance, the landscape must have worn from that on which we are accustomed to look! Odd, uncouth lepidodendra of arborescent growth, huge reed-like calamites, gigantic ferns stretched in interminable forests, clothed in one unvaried tint of sombre green. How different is the scene which Nature now presents!—mountains glowing with the purple bloom of heather; hillsides where the furze has spread its cloth of gold; meadows bright with daisies, ranunculi, and cuckoo-flowers; banks where the wild thyme and bluebell grow! The contrast affords a hint of the transformation in our world effected by the introduction of flowers.

Our knowledge may not enable us to describe all the minute steps which led to this remarkable change, but we can at least indicate with great probability the nature of the process and some of the agencies which contributed to bring about this result. To suppose that each species of plant was independently created as we now see it, implies not one creation merely but many successive creations; moreover, it leaves unexplained all the curious affinities which exist among the members of the vegetable kingdom. The gradations of structure, the geological succession and the peculiarities of plant growth are much more intelligible when we view the plants which now inhabit the earth as the lineal descendants of those which lived during the earlier ages of geology. From the nature of the case, the theory of development does not admit of actual demonstration; still the evidence in support of it is such that its advocates are entitled to claim a verdict on the mass of indirect and circumstantial evidence.

Among palæozoic cryptogams we have evidence of the existence of structures which, with comparatively little modification, might be converted into what we now regard as flowers. The abundant remains of lepidodendra in the coal measures testify to the important place attained by the group of lycopods, or club mosses, in the Palæozoic flora. To this family might very well have belonged the archetype from which our modern blossom-bearing plants have come. Our knowledge of this group is derived both from fossil remains and from forms still extant. The selaginellas, so commonly cultivated in greenhouses, are examples; also the little club moss, *Lycopodium selaginoides*, of our highland moors. The last mentioned, though a diminutive form, possesses special interest, being one of the few vascular cryptogams native to this country which produce two kinds of spores. This heterosporous character was, however, a common feature of extinct lycopods; both large and small spores have been detected in great numbers in coal.

The internal anatomy of the lycopodiaceæ is somewhat complex, but their external organization is simple. A club moss consists of a cylindrical stem covered with overlapping leaves, spirally arranged, of small size relatively to the stem, and always simple or undivided. The stem branches in a peculiar forked manner, which gives the plant its characteristic candelabra-like form. Existing lycopods are creeping plants, seldom exceeding two feet in height, but many extinct species attained the dimensions of large trees. On the ends of certain branches the leaves are crowded together, giving the terminal portion of each shoot some resemblance to a pine-cone. The crowded leaves on this portion bear, on their upper surfaces, little sacs called sporangia. Certain of these sacs contain very numerous small rounded bodies, the microspores; others have fewer spores of larger size, distinguished as macrospores. Sacs containing the small male spores are termed microsporangia; those having the large female spores, macrosporangia. When ripe, a sporangium bursts and discharges its spores, which are scattered by the wind. Should a spore alight on a favourable spot, it germinates after a time and gives rise to a structure called a prothallus, which is really an independent plant. This stage in the life-history of a cryptogam is, however, much better seen in ferns, where the prothallus is entirely expelled from the spore and attains a higher degree of independent development. The prothallus throws out root-hairs, nourishes itself and grows, but the leaf-like form it assumes bears not the remotest resemblance to the parent fern from which it sprang. This phenomenon, characteristic of the higher cryptogams, is known as the "alternation of generations." Similar phases are observed in certain animals, the medusæ or jelly fishes for example. In the course of its development a fern passes through two distinct phases; first, the spore-bearing stage or sporophyte, represented by the fern frond; secondly, the egg-bearing stage, the oöphyte or prothallus. As we ascend in the scale of vegetable life, the egg-bearing or sexual generation diminishes in importance, while the sporophyte preponderates more and more. In club mosses the prothallus has all but lost its independence; in the case of selaginella it is formed almost entirely within the spore, only a small part being extruded when the spore ruptures. Some of the lycopods are isosporous—that is, they have, like the ferns, but one kind of spore. Where this is the case, the prothallus developed from the spore bears two sets of sexual organs; the prothallus of one of the heterosporous cryptogams, on the other hand, produces sexual organs of one kind only. Antheridia appear on the prothallus developed from a small spore; archegonia on that from a large one. The former are the male organs, and from them are emitted numerous antherozoids, minute ciliated bodies, which swarm over damp surfaces in all directions. The archegonia are microscopic flasks, each containing an egg-cell or oösphere; they are entered by one or more of the locomotive antherozoids, which coalesce with the egg-cell; the latter is thereby fertilized, and soon grows by cell division into a plant resembling

that from which the spores were originally obtained. The life-history of a vascular cryptogam is, so to speak, a story completed in two volumes.

Microscopic research has revealed a most interesting relationship between flowering plants and the heterosporous cryptogams. When the development of the pollen grain in the anther of an ordinary flower is studied and compared with that of a microspore, the two are found to agree in a remarkable manner. The sporangium corresponds in all essential points with the pollen-sac, and its generating tissue develops in similar fashion to that from which the pollen grains originate. In both cases an archesporium is produced by the division of a hypodermal cell; this tissue next divides into a tapetal layer and a row of mother-cells; the tapetal layer dissolves, isolating the mother-cells, each of which then forms in its interior four daughter-cells, which are the spores or pollen grains as the case may be. Not only are the antecedents of microspores and pollen grains alike, but their subsequent histories offer many points of resemblance. Pollen grains are known in numerous instances to form in their interior one or more vegetative cells, which can hardly be regarded as other than a rudimentary male prothallus, such as is commonly developed by a microspore.

There is another bond of connection between flowering and flowerless plants of equal or even greater importance. In the interior of the ovule, or young seed, both of angiosperms and gymnosperms a special cell is developed, called the embryo-sac. When the history of this cell is traced back its development is found to be exactly that of a spore. Certain structures are also formed in its interior bearing the closest analogy to the internal prothallus observed in the macrospore of selaginella. These are most obvious in the embryo-sacs of gymnosperms, where the prothallus is represented by the endosperm, while the corpuscula, or secondary embryo-sacs, arising on this are the undoubted equivalents of the archegonia of ferns and other cryptogams. The gymnosperms thus stand midway between vascular cryptogams and angiosperms; but even within the embryo-sac of the latter, in the so-called antipodal cells, may still be detected vestiges of the oöphyte or sexual generation, that structure so characteristic of the flowerless class.

An alternation of generations can thus be traced throughout the greater part of the vegetable kingdom, from the lowest scale mosses through the urn mosses, ferns, horsetails, lycopods, and conifers, up to the highest members of the phanerogamic division. But of more importance for our present purpose is the certain identification of the pollen grain and embryo-sac of flowering plants with the microspore and macrospore of the older cryptogams. The stamen of a flower turns out to be simply a peculiar form of microsporangium, while the ovule is a macrosporangium, containing but one macrospore, or occasionally developing several. It follows, therefore, that we have only to enlarge our conception sufficiently to see in the spore-bearing cones of the lycopods structures of essentially the same nature as flowers. All the materials that go to the making of a flower could thus have been furnished by the flowerless flora of Palæozoic ages.

An important change, which marked the transition from cryptogams to flowering plants, must now be mentioned, and to this the animal kingdom furnishes a striking analogy. The lowest vertebrates, such as fishes, are oviparous; the ova are discharged and afterwards incubated. Mammals, on the other hand, are viviparous; the young are hatched within the body of the parent. The young of the kangaroo and other marsupials, which constitute the lowest order of mammals, are still very immature at birth. Analogous conditions are found among plants. Cryptogams are all oviparous; the macrospore, which may be regarded as the ovum or egg, separates from the parent plant before fertilization. Phanerogams, on the other hand, may be described as viviparous, since they retain the macrospore or ovum until it has developed an embryo. The presence of an embryo constitutes the distinction between a seed and a spore. Unless an embryo be present a seed cannot germinate, since germination is simply the emergence of the embryo from the coats of the seed. An extreme case of this retention is seen in the mangrove, where the seed germinates while still attached to the tree; the embryo sends down its long radicle into the mud, and only quits its hold of the parent when it has become firmly established. Orchids and many parasitic plants have seeds with exceedingly minute and imperfect embryos, recalling the undeveloped offspring of the marsupials.

The retention of the egg is attended with a manifest advantage; plainly the viviparous method of reproduction, which obtains in the higher divisions of the two organic kingdoms, is much more economical than the other. By the change to the viviparous condition several structures present in the cryptogams are rendered useless, and a disused organ invariably degenerates; the prothallus and its adjuncts, having no longer any function to perform, must inevitably begin to atrophy. The rudimentary structures appearing in the embryo-sac of phanerogams can in this way be accounted for. The life-history of a cryptogam extends, as we have seen, to two volumes; it now appears that the life-history of a phanerogam is a second edition of the same story, somewhat abridged and completed in a single volume.

The life-history of certain ferns occasionally undergoes a corresponding abbreviation. In the phenomena of apospory and apogamy we have departures from the ordinary course of development, closely akin to what would be required for the conversion of a cryptogam into a phanerogam. Apospory occurs when the production of spores is omitted, the prothallus growing immediately on the fern frond; apogamy, when the female organs are not developed, and the frond is formed by vegetative growth directly from the prothallus.

There is another fact of which account must be taken. In different groups of plants, in proportion to the complexity of their organization, the female cell tends to increase in size and importance. This is probably accompanied by a chemical or physiological enrichment of the substance of the egg-cell, rendering a higher degree of protection desirable. The enclosure of the embryo-sac within the ovule becomes in these circumstances an advantage. But by this investment, and by the ovule remaining attached to the parent plant, the microspore is of necessity reduced to the condition of a parasite, and the conversion of the male prothallus into a pollen tube becomes intelligible as a case of degeneration.

The closed seed-vessel of angiosperms, there can be little doubt, has in like manner been acquired for the purpose of excluding fungus spores, bacteria, and other destructive germs from the ovules. Van Tieghem found that when the pistil of a flower was opened the ovules could not be directly fertilized, but were invariably attacked by bacteria. The resinous secretions of conifers act as a germicide, rendering less essential the protection of the seeds, which is the *rôle* of the pistil in angiosperms.

The gradations between stamens, petals, and sepals seen in the water lily, and the conversion of stamens into petals in the garden rose, suggest a possible variation which would explain the first appearance of the floral envelopes.

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The nectary may not improbably be a transformed water gland, turned to account as an attraction to visitors, and so of use in promoting cross-fertilization. Every new character tending directly or indirectly to secure this advantage would be perpetuated; the colours, perfumes, mechanism, and most of the peculiarities of flowers become intelligible when viewed as results due to the selective agency of insects. But the steps by which the mutual adaptations of flowers and insects have arisen is a subject demanding treatment by itself, and on which we cannot enter at present.

IS BETA LYRÆ A DOUBLE STAR?

By MISS A. M. CLERKE, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century," &c., &c.*

ON the 10th of September, 1784, John Goodricke, of York, discovered a bright white star in the Lyre to be variable. He was a deaf-mute, scarcely twenty years of age, and died before he was twenty-two; but he contrived to ascertain the main features of its light-change. They are very peculiar. In a period of twelve days and nearly twenty-two hours, four phases of approximately equal duration are comprised. The light-curve represented in Fig. 1 is perfectly symmetrical. The twin-maxima are situated just midway between the unequal minima, and the measure of their brilliancy is, time after time, filled to the brim, without overflow or defect. Neither an abortive nor an excessive maximum has ever been recorded in Beta Lyræ. The intensity of the chief minimum is also—within observational limits—absolutely constant. So that the entire compass of variation, from 4·4 to 3·4 magnitude, is a fixed

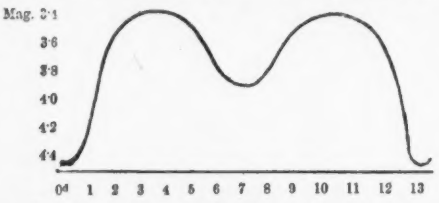

FIG. 1.—Light-curve of β Lyræ (Argelander).

quantity. The secondary minimum, however, does not show the same immutability. Its occasional exaggeration, by which the period is threatened with bisection, is balanced by recurring deficiencies of emphasis. But the flow of change is always smooth; it is interrupted by neither zigzags nor dead-level passages. Intervals of stedfastness, no less than flickerings in lustre, seem foreign to the character of this remarkable object, which traverses its cycle without ever, so to speak, getting off the rails. No single phase encroaches upon the next; anticipated maxima, retarded minima, are unknown. Nevertheless, the entire period is lengthening, and has been lengthening during the past hundred years, at the average rate of about one-third of a second at each recurrence. We have yet to learn whether this perturbation is of a compensatory nature. In either case, we can scarcely refrain from connecting it with disturbed orbital revolution.

Beta Lyræ displays an exceedingly curious and beautiful spectrum. The bright lines noticed in it in the first days of stellar spectroscopy by Father Secchi, were found, by M. Von Gothard in 1883, subject to what seemed like fits and starts of invisibility. Visual observation proved, however, altogether inadequate to the investigation of a highly complex phenomenon; and it was not until the aid of the camera became available that even its most essential characteristics were recognized. The duplex nature of this star's spectrum was detected at Harvard College Observatory in 1891. Mrs. Fleming's examination of twenty-nine Draper Memorial plates showed all the chief bright lines to be coupled with dark ones. This, at the time, unprecedented arrangement was repeated in Nova Aurigæ, and again last year in Nova Normæ. All three spectra, too, were of the Orion type, and in all three the great solar prominence-line, K, was bright and broad. But while the bracketed rays continued, in the "new stars," relatively fixed, they execute in Beta Lyræ certain mutual evolutions unmistakably connected with the periodicity of the object. The relation, it is true, is not direct or immediate; yet the processes of light-change and line-change cannot be regarded as otherwise than, in the long run, concurrent. Prof. Pickering accordingly suggested that the Lyra variable is really a binary system composed of a gaseous mass revolving in a period of nearly thirteen days round a star of the same physical constitution with Rigel. The opposite motion-displacements of the bright and dark lines indicated, according to his estimate, a relative velocity of three hundred miles a second in a circular orbit, the moving bodies being fifty millions of miles apart. No attempt was made to explain the fluctuations of their joint brightness. Father Sidgreaves, however, who has made this star the object of an interesting research,* favours the theory of an alternate eclipse by and of its supposed gaseous attendant, combined with tidal action producing both spectral and luminous variations. But the *rationale* thus offered is hampered by serious, perhaps by insuperable, difficulties.

Let us look steadily for a moment at the conditions of the problem. It is admitted on all hands, to begin with, that the star's telescopic variability depends wholly upon the waxing and waning of its continuous spectrum—representing, presumably, its photospheric emissions. The fading of brilliant rays, or the deepening of dark ones, has no perceptible effect upon the sum-total of light. The observed changes in its *quantity* and *quality* are, then, correlated effects of a single cause. The former are perfectly definite, both as to time and amount; the latter, amid many seeming caprices, obey fundamently the same law of recurrence. If the law be prescribed by orbital motion, then the two kinds of variability must be capable of explanation through the known results of such motion, to the exclusion of contradictory conditions. But attempts to provide, on this basis, a complete explanation of the phenomena have hitherto led to nothing but entanglement in a mesh of baffling inconsistencies.

The possible alterations through orbital movement in the light reaching us from a binary system may be classified as optical and physical. Occultation-effects, distortion-effects, and line-shiftings produced by radial velocity are of the first kind. They represent no actual changes. They are compatible with an absolute constancy in the state of the system, since they depend merely upon the varying relations to the line of sight of the bodies forming it. With the physical consequences, as regards luminous emission, of close duplicity, we have only a speculative acquaintance. It may be that the tidal disturbance at a periastral rush-past would occasion eruptive outbreaks associated with sudden accesses of brightness; but the "tidal theory" of temporary stars does not apply to the object of our present discussion. For two reasons: First, because the path of the stars thus affected should be a

* *Monthly Notices*, Vol. LIV., p. 96.

long ellipse, while that of Beta Lyræ can be inferred from the equal duration of its phases to be sensibly circular. Next, because the ebb and flow of light displayed in them is so tranquil as to exclude the possibility of their connection with any kind of explosive action.

We seem, then, thrown back upon some description of optical *rationale*. The most obvious is that of a double eclipse, the brighter object being obscured at the principal minima, the satellite at the subsidiary minima. This view has in fact been adopted both by Father Sidgreaves and by M. Belopolsky.* Yet the light-curve of Beta Lyræ is totally different from those of Algol and other ordinary eclipse stars. It represents continuous change, instead of a settled maximum, interrupted at fixed epochs by a comparatively swift decline and recovery. It would thus appear that the Lyra variable can be associated with Algol and its congeners only on one condition—that it is made up of two enormous orbs circulating in such exceedingly close contiguity that their mutual occultations form an almost unbroken series. If each were of the solar mass, the distance from centre to centre would then be roughly six and a half million miles. Admitting further the separation of their surfaces by an interval of one million, the diameter of each of the conjoined bodies, which, for the sake of simplicity, may be taken as equal, would be six millions of miles. They would accordingly be three hundred and thirty times rarer than the sun, their density exceeding that of air at the sea-level only about three and a third times. That globes thus tenuous should shine with stellar brilliancy does not seem probable, but one should hesitate to pronounce it impossible.

Assuming their existence, we can safely assert that, although they might escape eclipse, they could not escape distortion through the inequalities of their mutual attraction. They would, in fact, not be globular, and their persistent extension along the line joining their centres, and corresponding compression in the opposite direction, would cause them to present to our view (if the plane of their orbit made only a small angle with the visual ray) a larger luminous area when *broad-side-on* than when *end-on*. And since the range of variability in Beta Lyræ is of one magnitude, the joint extent of surface visible respectively at the elongations and conjunctions of the pair should be in the proportion of two and a half to one. The disparity of their alternate minima would, indeed, offer a difficulty, but it might be successfully met by an ingenious contriver of hypotheses. All that we are at present concerned to establish is that the periodical loss of light in this star, if an optical effect of revolution in an orbit, can only occur when its components are crossing our line of sight.

The spectroscopic evidence on the same point may now be glanced at. Visually indivisible binaries, moving in a plane passing nearly through the earth, show a double spectrum at elongations, a single spectrum at conjunctions. That is to say, the coupled lines in the dispersed light of the companion-suns are separated to the utmost when the entire orbital velocity is directed along the line of sight, but coincide when it is directed across it. These regularly alternating effects are, nevertheless, very imperfectly, if at all, recognizable in Beta Lyræ. The extraordinarily complex nature of the problem with which astronomers are thus confronted is emphasized by the splendid series of spectrograms taken at Potsdam, mainly by Dr. Wilsing, in 1892-3, and discussed, in his usual masterly style, by Dr. Vogel.† The prismatic section depicted in them lies between wave-lengths 450 and 380, so that they include the remarkable line at λ 447 together with a considerable extent of the ultra-violet radiations. They are, besides, unprecedentedly numerous, and appear to be of pre-eminent definition, constituting altogether a stock of materials of the very highest importance.

The spectral changes in this star are particularly well-accentuated in the line H ζ, as the first member of the ultra-violet hydrogen-sequence is termed in the new system of nomenclature introduced by Dr. Vogel. The accompanying figures, reproduced by his kind permission, show its characteristic aspects at the four critical epochs of light-fluctuation. In Fig. 3 we see its condition at the principal minimum. A brilliant wide ray lies on the red or less refrangible side of an equally wide dark ray. The ensuing maximum (Fig. 4) brings little alteration ; only a slight brightening comes in on the violet side of the absorption. At the second minimum, however, a totally different state of things is seen to prevail (Fig. 5). The black line is projected upon a much broader bright band. And the next maximum (Fig. 6) unexpectedly follows suit. The chief minima of the star, then, take place when the H ζ lines are furthest separated; and the remaining hydrogen and other lines tell the same story. This is as much as to say that these mysterious obscurations are *not* due to eclipses, which are, of course, geometrically impossible except when the occulted and occulting bodies are travelling straight athwart the line of sight. An additional circumstance of great perplexity is the spectroscopic correspondence of adjacent, and not, as would naturally be looked for, of opposite phases of luminous variation. It obliges us to discard utterly the supposition of motion-displacements in a nearly circular track ; unless, indeed, we are permitted to bring to the rescue a swift translation through space of the entire system. This would also account for the unsymmetrical character of the recorded line-shiftings, for the bright lines travel very much further from the dark ones towards the red than towards the blue, the compensatory swing being almost null. But we can arrive at no reliable conclusion on this point until Dr. Vogel carries out his intention of measuring these shiftings with the help of a comparison-spectrum. Information as to their absolute values, their progress and plan, will then be forthcoming. It is true that the width and close juxtaposition of the lines interpose serious obstacles to the success of such operations; but at Potsdam, if anywhere, they will be overcome.

An inspection of Dr. Vogel's beautiful drawings suggests,

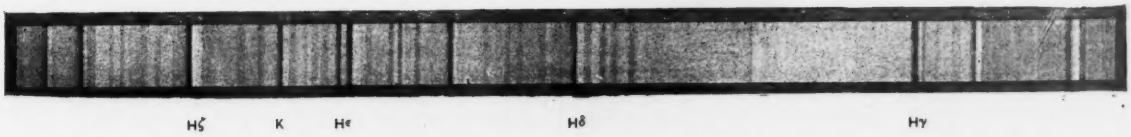

FIG. 2.—General Spectrum of β Lyræ from wave-length λ 380 to λ 450. Reproduced from paper of Dr. Vogel, published in the *Sitzungsberichte* of the Berlin Acad. d. Wiss, February 8th, 1894.

* *Memorie degli Spettroscopisti Italiani*, t. XXII., June, 1893.

† *Sitzungsberichte*, Berlin, 8th February, 1894.

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however, a further complication. Light emanating from a double source can, under certain circumstances, be distinguished spectroscopically from light derived from a single source. Appearances impossible in the one case expound themselves naturally in the other. Reflecting for a moment upon the origin of a double spectrum composed of contiguous bright and dark lines, we see plainly that the

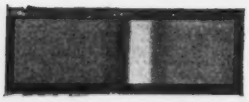

Fig. 3.—Principal Minimum.

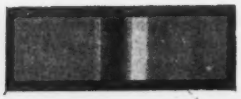

Fig. 4.—First Maximum.

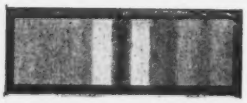

Fig. 5.—Secondary Minimum.

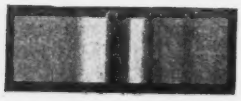

Fig. 6.—Second Maximum.

Changes in the Hζ Region of the β Lyræ Spectrum. The red end of the Spectrum is to the right hand.

corresponding sets can show separately only through the effects of relative displacements, in the absence of which the combined spectrum should represent the simple summation, wave-length for wave-length, of all the rays received into the telescope. Not an algebraic summation. There are no negative quantities. The darkest ray cannot sink below the zero-level of light. Hence the vivid rays lose none of their brightness by subtraction; they must, on the contrary, show more distinctly on an obscured background. Dark lines, accordingly, can never be seen projected upon bright ones emitted by a companion luminary. But look at Figs. 5 and 6. They exhibit an absolute cutting-out, at the second maxima and minima of Beta Lyræ, of part of the brilliant H ζ! They exhibit, in fact, a phenomenon entirely inconsistent with the hypothesis

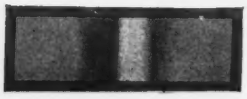

Fig. 7.—The Hγ line at the Principal Minimum.

Fig. 8.—λ 447 at the Principal Minimum.

that the superposed bright and dark bands originate in separate stars. The effect is almost demonstrably due to real absorption by a cooler overlaying an intensely glowing stratum of hydrogen in the atmosphere of a single body. It would seem to be perfectly analogous to the double reversals of the calcium K-line in Prof. Hale's photographs of solar prominences. In the Lyra variable, then, double reversals must be held to play a part in producing spectral change. Motion-displacements are doubtless also present, although they cannot be solely effective. There are other items of evidence, too, proving the variations in this wonderful spectrum to be in part optical, in part physical.

Recapitulating, we find that the eclipse theory of light-change, in itself applicable only with extreme difficulty to the circumstances of this star, is directly negatived by patent spectroscopic facts. The incompatibility is fully recognized by Dr. Vogel. He gives, indeed, a general assent to the view that Beta Lyræ is a binary combination, the period of which dominates the variations in the kind and amount of its light, but prudently refrains for the present from attempting to explain the detailed peculiarities and irregularities disclosed on about one hundred and thirty of his spectrographic plates. Before these can all be included under a common formula, knowledge must obviously be greatly and variously increased—a consummation only to be brought about by working diligently and waiting patiently.

THE FATIGUE OF METALS, AND MUSCULAR FATIGUE.

By D. S. Smart.

In common language we use the words *weariness* and *fatigue* almost indiscriminately, and as synonymous terms to describe physical exhaustion. To the engineer, however, the term *fatigue*, as applied to metals, carries a technical significance which the expression *weariness* does not cover; but it would appear from the following facts that the technical word *fatigue*, as applied to metals, may with equal propriety be applied to muscles.

Fatigue of metals is a phrase which has only come into use within recent years, and it describes a condition of the material not previously understood. The expression stands for a straining of the relationship to each other of the molecules of which the metal is constituted, a meaning which the term *weariness*, or literally *worn-ness*, does not convey.

It is a matter of constant experience amongst engineers that parts of machinery break down after having worked satisfactorily, and apparently with safety for months, or it may be for years—ten, fifteen, or even twenty years. The cause of such breakages was long a mystery, but is so no more; they are the result of *fatigue*. We take advantage of this principle when we break a piece of wire; we bend it backwards and forwards until rupture takes place—from *fatigue*.

In the metals there is a point in their resistance to pulling, bending, or crushing, known as the elastic limit, the point at which permanent strain commences. The elastic limit of iron or mild steel, for example, in their normal condition, is reached, roughly speaking, when about half the breaking load is applied. If the stresses brought to bear upon a piece of metal are within this limit it will sustain these stresses without injury, however long they may be applied. If the stresses exceed the elastic limit, in however small a degree, *fatigue* of the metal will result, and, if they are continued, breakage sooner or later will inevitably take place. To guard against accident from such insidious *fatigue*, it has now become usual, in the best practice, to withdraw permanently from use parts of machinery, such as railway crank and carriage axles, upon the soundness of which the safety of many lives may depend, after they have performed a certain number of revolutions, even although no flaw or sign of injury can be detected.

If, however, metals are strained beyond the elastic limit, but not broken, and if the straining is not continued, the material will recover its elasticity by rest alone. Some years ago, Prof. B. W. Kennedy demonstrated by many experiments the recuperative property of metals after *fatigue*. Bars of iron and steel, strained in a testing machine beyond the elastic limit, and so weakened thereby that if they were tested again the following day they would take permanent set at one-third or less of their former load, would, if allowed to rest for about two years, be found not only to have recovered their original elastic

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PHOTOGRAPH OF THE η ARGÛS NEBULA.

Taken by Mr. H. C. RUSSELL, Director of the Sydney Observatory, with Astro-Photo-telescope of thirteen inches aperture, and eleven feet three and a half inches focal length. Exposure of five hours forty-three minutes.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

Exposure of the Screen [illegible]

Direct Photo Engraving Co., 9, Barnsbury Park, N.

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limit of strength, but to have exceeded it, and to have become stronger than before in the direction in which they had been pulled. If the period of rest was materially shortened, the restoration of strength was found to be incomplete.

Now let us consider how far *fatigue* in this technical sense is applicable to muscles as well as to metals. Prof. Michael Foster, in his Cambridge University Rede Lecture last year, pointed out that the muscles in the leg of a frog severed from the body, and caused under electrical stimulus to exert themselves in work until thoroughly *wearied*, to use his own expression, and no longer able to respond to the electrical excitement, will, with rest alone, recover their elasticity and be able to resume work as before. Prof. Foster demonstrated that the weariness was in the muscle and not in the nerve. These severed muscles were cut off from any new supplies of strengthening material, and also from any replenishing of vital force, and yet they recovered tone by rest alone. It is therefore evident that this renewed vigour was due solely to the readjustment or rearrangement of molecules—to their recovery to a state of repose. The worn tissues we know could not be restored, but from the *fatigue* the muscles did recover, and it is therefore clear that the fatigue which we experience in our own bodies must be largely *fatigue* in the technical sense in addition to *weariness* proper, or *worn-ness*. Rest is therefore required, not only to enable wasted tissues to be restored by fresh material from the blood, and by the carrying away of waste material, but also to afford opportunity for the strained molecules to recover a state of repose.

In iron or steel which has been strained, a more rapid restoration of the molecules to a state of repose is effected by heating to redness and cooling slowly. This process is termed annealing, and is regularly adopted to take the *fatigue* out of chains, the strength of which has been taxed, and out of any piece or plate of iron or steel which has been much mauled in getting it to shape. In copper, the same result is accomplished by heating to redness and quenching in water.

If a piece of machinery is of ample strength for its work it does not undergo *fatigue*, and is safe for any length of time if not worn out by friction or by rust. In like manner it is only those parts of our bodies which are too light for their work which become really *fatigued*. If one is accustomed only to very light work, he becomes *fatigued* when he undertakes heavier work. His muscles are unfitted for it, and are consequently strained. In fact, all heavy work is *fatiguing*, because our bodies are only fitted for the average work of the race, and if heavy work were to be done without excessive *fatigue*, special training through many generations would be required. For work only a little above the average, a course of training is necessary. If, as in the case of machinery, the bodies of men and animals were unprovided with a sensitive nervous system to register *fatigue* and demand rest, we should continually be having sprained and ruptured muscles and broken bones. But some of the muscles, such as the heart and the muscles of the chest used in breathing, although in practically continuous action, are yet fairly equal to their work, and unless exercised in an exceptional manner, experience little or no actual *fatigue*. They, however, of course, share in the drain of vital force which accompanies *fatigue* and *weariness* in any part of the body. It has been pointed out that, although the heart appears to work continuously, it really does its work expeditiously, and finds time for a considerable amount of rest between the beats, especially during sleep. The necessity for such rest, however, is apparent, quite apart from any theory of *fatigue* in the technical sense, as the rest is evidently required in which to repair the waste of tissue and of unguent which must continually be going on.

Prof. Foster further showed that if the severed but still palpitating heart of a tortoise were washed with water containing salt, some constituent of its strength would be washed out, and the palpitations would cease, but that on the application of a little lime-water the strength would be restored, and the heart would again commence to beat. Such recovery of tone cannot be due to the addition of living cells such as might take place in the living heart when incorporated in the living body, or the carrying away of waste material, and can only result from change in the muscular tissue, such as is involved in the absorption by the impoverished molecules, through chemical affinity, of their required nourishment. But such absorption is not a property of muscular tissue alone. A similar process takes place when iron becomes converted into steel by the absorption of carbon in the case-hardening process. Strips of iron can also be converted by this process into strips of steel, their strength being about doubled. The iron is simply heated and kept in contact with carbonaceous matter until the absorption is complete.

STAR CLUSTERS IN THE η ARGÛS REGION OF THE MILKY WAY.

By A. C. RANYARD.

THE great nebulous stream which stretches across the heavens in the Northern and in the Southern Hemisphere is far from being a uniform ring of nebulosity spangled with stars. When different regions of the Milky Way are examined in detail, they are found to exhibit local peculiarities which are not recognized on a survey of the heavens with the naked eye.

Such differences of nebulosity and stellar condensation seem to indicate that the different parts of this immense cosmical structure are not identical in constitution, or, if we assume that the various chemical elements are uniformly distributed in space, such a want of homogeneity tells a tale of vast differences in the conditions under which the various parts of the galactic system have assumed their present form.

That the Milky Way is far from homogeneous was distinctly recognized by Sir John Herschel during his telescopic survey of the heavens, and now that, with the aid of the camera, we are able to place accurate pictures of different parts of the Milky Way side by side for comparison, the characteristic differences exhibited by different regions of the nebulous stream become still more apparent. In speaking of the η Argûs region of the Milky Way shown in our plate, Sir John Herschel (in the *Cape Observations*, p. 33) described it as composed of stars of larger average magnitude than other parts of the Milky Way, grouped into a series of clusters separated by a number of darker patches and lanes. In other parts of the Milky Way the nebulosity is comparatively uniform; in others, again, it is flocculent, as Sir John Herschel described it, "like clouds passing in a *scud*." The whole of the southern half of the Milky Way appears to be rather more coarse-grained than the northern half, and it is rather more thickly spangled with naked-eye stars.

Such differences of constitution in different directions is alone sufficient to negative the supposition that the Milky Way is the projection on the heavens of a stratum of stellar condensation, which corresponds, as it were, to a

stellar ecliptic plane in which the sun and the majority of the stars are moving. If we were looking through a vista of stars which extended to a great depth in every part of the Milky Way, such differences of constitution in different directions would indicate a radial distribution of the different types of structure about the sun's place, and would involve the assumption that the sun occupies the centre of the system, and that the material of the universe is arranged symmetrically in sectors about it, an assumption which is abhorrent to modern ideas, and irreconcilable with what we know of the proper motions of the sun and stars.

The assumption that the Milky Way corresponds to a stratum of stars also involves other difficulties, for we must account for the fact that the galactic stream of nebulosity and thickly clustered stars is split into two streams through half of its course round the heavens, and also for the fact that the main streams are again divided and branched. If we hold to the assumption that these streams and branches correspond to a stratum of considerable thickness in a direction radial to the sun's place, the form of the galactic system becomes very complicated. It is evidently altogether simpler to assume that the streams have a thickness which does not differ greatly from their apparent breadth.

The photographic evidence which we now possess does not indicate that the streams have the definitely defined boundaries which they were thought to possess by Mr. Proctor and the old school of map makers, who had to rely chiefly on drawings made with the naked eye. If the Milky Way pictures which have been published in KNOWLEDGE are examined, they will be found to show no very definite outlines of the galactic streams, and no clearly recognizable central core, dark lanes or streams of stars running parallel with the axis of the galactic stream. In our second plate, reproduced from a photograph of the region about the η Argûs nebula taken by Mr. Russell with a large camera, the general axis of the Milky Way stream runs horrizontally across the page, but there is no marked condensation of stars or nebulosity at the centre of the stream, and the curiously contorted stream lines of stars which are recognizable seem to be inclined at all angles to the axis of the great stream of the Milky Way.

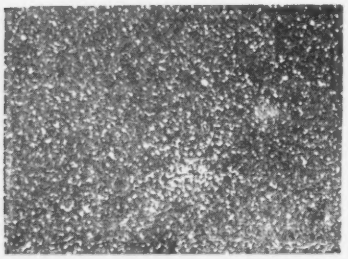

FIG. 1.—Cluster with radiating streams of Stars on the left or following side of the γ Argûs Nebula.

There can be no doubt about the general parallelism of arrangement over the heavens of certain classes of objects with respect to the Milky Way; thus the smaller nebulæ are grouped around the galactic poles, and there is a marked absence of them in the neighbourhood of the Milky Way. The larger nebulæ and clusters, on the other hand, are intimately associated with the distribution of the lucid matter and stars of the Milky Way. The aggregation of star clusters upon the Milky Way, especially along its central region, is very strikingly shown in the map published by Mr. Proctor and Mr. Waters in the *Monthly Notices* of the Royal Astronomical Society for August, 1873. The stars exhibiting a bright line spectrum are also distributed along the central axis of the Milky Way; and it has long been known that the brighter stars all over the heavens show a general arrangement with respect to the Milky Way, and a general tendency to cluster towards it, so that they, or a large proportion of them, must be in some way connected with the Milky Way system.* It is evident, therefore, that a large proportion of the matter which our sense of sight reveals to us is controlled by, or at all events is symmetrically arranged with respect to, matter distributed along the axis of the Milky Way.

In the photograph of the region we have before us, we have an opportunity of studying clusters and streams of stars which probably are actually as well as apparently in close proximity to the axis of symmetry around which the visible universe, or a large part of it, is symmetrically arranged, and we naturally look for evidence of condensation along the central axis, or for some evidence indicating motion around the central axis, but we look in vain.

In the star clusters which we are able to study in various parts of the heavens, a central condensation is not always to be detected. Thus the Pleiades and Hyades hardly show any evidence of condensation towards a centre; the clusters in the sword hand of Perseus may be taken as an intermediate type in which there is partial condensation or

FIG. 2.—The γ Argûs Nebula with radiating Star Streams, the position of which has been roughly indicated by scratches on the block.

crowding towards a centre, and at the other end of the scale we have clusters like that shown in Fig. 1, or like the still more centralized cluster in Hercules, photographs of which were given in the May and June numbers of KNOWLEDGE for last year (1893.)

In the cluster shown in Fig. 1 and in the Hercules cluster, as well as in the photographs of all similarly condensed clusters which I have had an opportunity of examining, the central mass or group of stars is surrounded by radiating streams of stars which branch in a direction away from the centre of the cluster, and the central mass is associated with dark structures or light-absorbing masses evidently situated between the eye and the nebulous background or haze about the central stars.

The presence of an attracting mass at the centre of a cluster is evidenced not by curves of stars concentric with the centre, but by streams of stars which appear to spring from the centre and break into branches in a direction away from the centre. Similarly we should expect to find the presence of an attracting mass, or attracting masses, arranged along the centre of the Milky Way stream evidenced by chains of stars associated with dark branching structures. If the streams of stars and dark structures were arranged radially with respect to the axis of the Milky Way, we should expect to find the best evidence of the radiating structure at the edges of the stream and not at its centre, where we should look down upon such radiating streams vertically.

* Our own sun, and other swiftly moving stars, may not be so connected.

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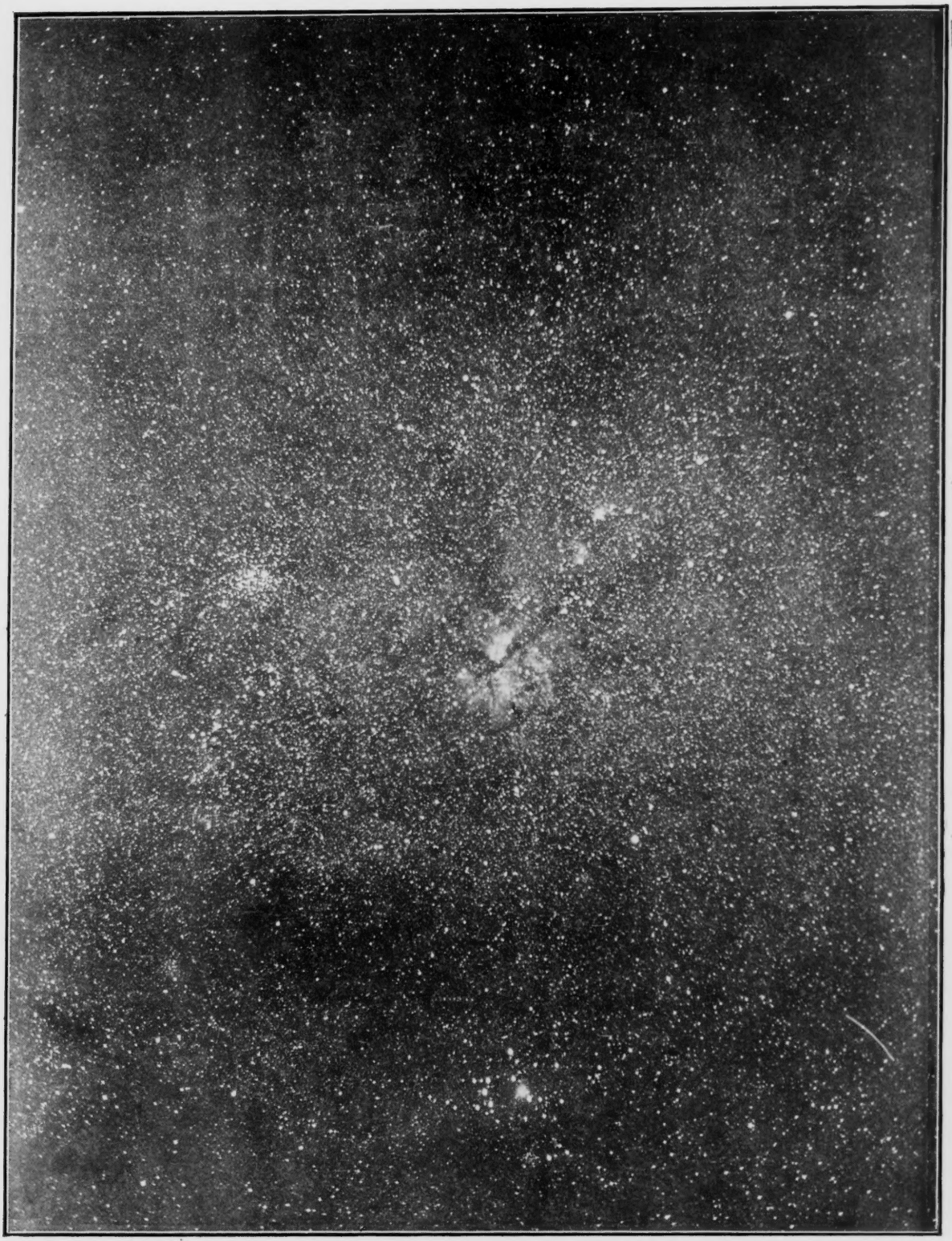

PRECEDING.

THE REGION OF THE MILKY WAY ABOUT η ARGÛS, SHOWING NEIGHBOURING CLUSTERS AND ASSOCIATED STAR STREAMS.

From a photograph taken by Mr. H. C. RUSSELL at the Sydney Observatory, with a Dallmeyer six-inch portrait lens of thirty-two inches focus, and an exposure of eight hours. Scale of reproduction 1° = 0·65 inch.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

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That we fail to find such a parallel arrangement of diverging streams on either side of the Milky Way seems to indicate that the stream of the Milky Way bears a closer analogy to an open star cluster than to a cluster of the centrally condensed type.

The nebula about η Argûs is a very fine specimen of a nebulous cluster with a central condensation associated with dark structures and radiating streams of stars. Fig. 2 shows several streams of stars diverging from the central mass. (I have indicated the place of some of the most remarkable of these streams by scratches on the block.) The streams are in most cases accompanied by narrow black channels in the general nebulosity, which run parallel to and alongside of the star streams. The reader should examine these on the large plate. The radiating character of the great dark rifts, which entirely cut out the light from some parts of the central region of the cluster, is also well shown in this small scale picture of the nebula.

It is interesting to compare it with the larger photograph of the nebula reproduced in our first plate, as well as with the large scale photographs of this nebular cluster reproduced in the March and April numbers of KNOWLEDGE for last year (1893). Sir John Herschel was the first to point out the lines of stars bordering the edges of the great dark rifts in this nebular cluster. There can be no doubt about the intimate connection between the dark structures and lines of stars in this cluster.

The trifid character of the great dark rift which blots out the central regions of the η Argûs nebula may be worth noting in connection with the somewhat similar though fainter trifid rift in the Hercules cluster, which was first observed by the Earl of Rosse, and described by him as "three dark lanes meeting in a point." They are well shown in several protographs of the Hercules cluster which have been taken by the Brothers Henry, Dr. Isaac Roberts, and others. It may be worth noting, also, that there are some dark patches and dark structures in the central parts of the cluster shown in Fig. 1. They are just visible in our plate, but are better seen in the silver print from Mr. Russell's negative.

Fig. 3 shows some curious closed curves of stars forming a meshwork, and a circle of stars surrounding a comparatively dark area. In the light of other phenomena, it seems not improbable that such closed curves of stars, which are found in many parts of the Milky Way, may be due to star clusters, the central parts of which are obliterated by dark structures enveloping and cutting out the light from the central parts of the cluster. Fig. 3 also shows several narrow dark channels in the general nebulosity. Similar dark channels may be traced running over nearly all the brighter regions shown in our second plate. There are also several broader branching dark structures, one of which (immediately to the left or following side of the cluster shown in Fig. 1) evidently extends in front of the cluster, for its branches interfere with some of the streams of stars from the cluster, a fact which renders it probable that this cluster lies at some depth within the star stream of the Milky Way.

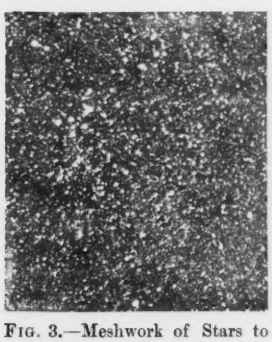

FIG. 3.—Meshwork of Stars to the South of cluster shown in Fig. 1.

LIQUID CHLORINE.

By A. G. BLOXAM.

THE critical temperature of chlorine gas,* or the temperature below which it must be cooled before it can be liquefied by pressure is about 33° C., so that this gas may be counted among those which are easily converted into liquids. Faraday first produced liquid chlorine, and described its colour as dark greenish-yellow; its specific gravity was afterwards determined to be 1·33, and its boiling-point 33·6° C.

It is very probable, however, that Faraday little dreamed of liquid chlorine as an article of commerce to be bought and sold by the hundredweight. He would, we imagine, have been rather hard put to it to suggest a material for the condensing pump and reservoir; though, in respect to his memory, be it said that a very few experiments could not have failed to furnish him with a solution to the problem.

The difficulties attending the production of chlorine, and the impossibility of transmitting it in the gaseous state, have combined to render chloride of lime in this country, and chloride of soda (*eau de javel*) in France, the only forms in which this indispensable bleaching agent can be put upon the market. When it is remembered that chloride of lime at its best does not contain more than 38 per cent. of "available chlorine," the advantage to be obtained in the matter of freight by transporting pure liquid chlorine instead of bleaching powder will be apparent.

The actual manufacture of liquid chlorine is now being undertaken by a firm of alkali-makers at Salindres, the process being conducted as follows, according to M. Fribourg:—

The condensing pump is provided with a piston of sulphuric acid, as being the packing best fitted to withstand the attack of the chlorine. To render such a piston effective, a pump of peculiar construction is of course essential. This takes the form of a U-shaped tube of cast-iron, lined with lead. The limb of this tube which is to receive the chlorine is partly filled with strong sulphuric acid, whilst the other limb contains petroleum oil, and is provided with an ordinary piston. The upstroke of the piston raises the petroleum, lowers the sulphuric acid, and allows the chlorine to flow into the vacuum thus formed, through a side tube provided with a leaden (?) valve; the downstroke compresses the chlorine through another pipe into the refrigerated receiver, re-entry into the generator being prevented by the leaden valve.

Such is the somewhat bald information connecting the compressing machinery, with which we have at present to remain satisfied. The receivers in which the liquid is transported are wrought-iron or steel cylinders, the necks of which are furnished with T-pieces carrying two bronze valves, the one connected with a tube reaching to the bottom of the receiver and destined to serve for withdrawing the liquid chlorine as such, the other serving for the withdrawal of gaseous chlorine. The cylinder weighs some 225 lbs., and is capable of containing 1 cwt. of liquid chlorine, or nearly 525 cubic feet of the gas. The pressure in the cylinder is 10 atmospheres at 35° C., but they are tested up to 100 atmospheres. The anhydrous chlorine has no action on the iron, bronze, and lead fittings.

It is proposed to sell small cylinders containing 10 lbs. of liquid chlorine for experimental use, so that the chemist may look forward to a day in the near future when his gas-generating flask shall be shelved once and for all, and his oxygen, hydrogen, nitrogen, carbonic acid, sulphurous acid, ammonia, chlorine, and sulphuretted hydrogen be at hand, each in its steel or glass cylinder.

* The article by M. FRIBOURG on Liquid Chlorine, from which the facts in this article are taken, appeared in a June number of *Bulletin Soc. Chim.*

Notices of Books.

Man the Primeval Savage; his haunts and relics from the hill-tops of Bedfordshire to Blackwall. By Worthington G. Smith. (Stanford, 1894.)—A most interesting and artistically illustrated book, in which the author describes, in "clear understandable words," several of his own researches, throwing light on the history and surroundings of palæolithic man in England. After the glacial epoch, when the boulder-clay was deposited, England seems to have been submerged to a great depth beneath an icy sea, where its surface received deposits of sea organisms; it then gradually rose till England was conjoined with that part of Europe now known as Northern France. The Thames, the Rhine and the Elbe were then tributaries of a great river which emptied itself into the North Sea; and the present English Channel was represented by a river which flowed towards the Atlantic, midway between Cornwall and the north coast of Brittany, and emptied itself into the Atlantic at a point to the west of where the Land's End now is. It is known that the Thames was then broad, and ran at a considerable height above its present level, depositing river gravel, sand and brick-earth, in terraces on the hillsides bordering its course. In these deposits the relics of primeval man first appear. In some localities such relics are comparatively abundant, not on the surface, but imbedded amongst the gravel, sand, or brick-earth, a hundred feet or more above the present river level. Palæolithic man seems to have wandered into what is now Great Britain from the mainland of Europe, and with him came the mammoth, or great hairy elephant, the rhinoceros, the lion, and the hyæna. But few relics of the bony fabric of the palæolithic savage remain, though the stone weapons and tools which he made use of are comparatively common; and Mr. Worthington Smith has found many other objects that he used, even wooden stakes, the points of which he sharpened with his rough stone implements. The book will be found easy reading and very instructive, both from a geological point of view and on account of the anthropological and archæological evidence which Mr. Worthington Smith brings before the reader in a most vivid manner.

Creatures of other Days. By the Rev. H. N. Hutchinson, B.A., F.G.S. (London, Chapman and Hall, 1894).—As Sir W. H. Flower remarks in his preface to this fascinating and interesting book, there must always be much that is mere guesswork in the restoration of the external appearance of extinct animals, known only by their bones and teeth, but Mr. Hutchinson and the accomplished artist, Mr. Smit, who has aided him, have both done their work very conscientiously, and have made use of much information that is not available to the general reader when he endeavours to reconstruct for himself the outward appearance of the ponderous uncouth mammals and enormous reptiles which held possession of the world for so many ages. We shall probably never know much more about the soft parts which have perished than can at the present time be gleaned from the skeletons, footprints, horns, and armour plates preserved in museums, though it is possible that in the future different interpretations may be placed upon obscure indications which are now imperfectly interpreted. The chapter on the horse and its ancestors is of special interest because of the wonderful series of fossil horses brought to light by geologists, and so clearly interpreted by Huxley, Marsh and other authorities. These remains constitute the most complete chain of evolution yet known to the palæontologist. When people inquire for the "missing links," he can point with satisfaction to the bones of ancient horses and show the gradual steps by which the little five-toed ancestor of the Eocene period gradually lost some of its toes, and took on other features till its descendants evolved into the noble animal of the present day. Most of the knowledge brought together by Mr. Hutchinson in this book is the outcome of the scientific work of the present century, and by far the greater part of it belongs to the second half of the century. It is difficult now to realize the ideas with regard to the past history of our globe which prevailed at the beginning of the century, when Cuvier, in 1804, from a study of the bones of the palæotherium, found in the celebrated gypsum quarries of Montmartre, near Paris, demonstrated for the first time to the satisfaction of the scientific world that vertebrated animals inhabited the earth in former times other than those now found upon its surface. The book is a sequel to Mr. Hutchinson's "Extinct Monsters," and will probably be still more popular.

The Economics of Commerce. By H. de B. Gibbins, M.A. (Methuen & Co., London, 1894.)—Mr. Gibbins' little book will be welcomed by those who want a concise and sound little manual on economic questions. At the end of each chapter, which deals with the subjects treated of in a simple as well as forcible manner, Mr. Gibbins gives valuable lists of the books and papers that should be consulted by those who wish to obtain a wider knowledge of the questions dealt with.

The Worlds of Space. By J. E. Gore (Innes & Co., London, 1894).—This is a collection of thirty-three very readable essays and articles on astronomical subjects, which have appeared at various times in *The Newbery House Magazine*, *Knowledge*, *The Gentleman's Magazine*, *The Sun*, and *Indian Engineering*. The publishers have reproduced very creditably many of the illustrations which have appeared in KNOWLEDGE.

The Art of Projection, and Complete Magic Lantern Manual. By an Expert (published by E. A. Beckett, London).—A well illustrated little book, giving several practical hints, and suggesting handy methods which will be found useful by lecturers.

The following books have also been received for review: *Our Country's Flowers and how to know them*, by W. J. Gordon, with an introduction by the Rev. George Henslow (Simpkin, Marshall, Hamilton, Kent & Co.); *Our Country's Birds and how to know them*, by W. J. Gordon (Simpkin, Marshall, Hamilton, Kent & Co.); *The Starry Skies: First Lessons on the Sun, Moon and Stars*, by Miss Agnes Giberne (Seeley & Co.); *The Amateur Telescopists' Handbook*, by Frank M. Gibson, Ph.D., LL.B. (Longmans, Green & Co.); *The Bluebook of Amateur Photographers for 1893* (Walter Sprange, London).

Science Notes.

Dr. Max Wolf is to be provided with a new observatory, which will be erected, at the cost of the city of Heidelberg, on the top of the "Gaisberg," about one thousand feet above the present university buildings. The Karlsruhe Observatory and its instruments is to be removed to the same spot, so that there will be a twin observatory on the summit of the "Gaisberg," the meridional department being superintended by Prof. Valentine, and the astro-physical department by Dr. Max Wolf, whose friends are providing him with a new and larger photographic instrument.

Mr. David Morris calls attention to the noteworthy discovery of the seeding of the sugar-cane, which has never before been observed, the cane having been entirely propagated by cuttings for many hundred years. By a curious coincidence a sugar-cane seeded both in Java and in the

East Indies in the same season. Some of the seeds were sent to Barbadoes and there planted, with extraordinary results, hardly any two of the plants produced being alike. Between some the differences were so great as to make them hardly recognizable as the same plant; one in particular was remarkable in having long roots springing from every joint in the stem. It is thought that many new and improved varieties might be produced if these plants could be induced to seed regularly.

Some beautiful photographs in colours of the solar spectrum have been taken by the improved method of M. Lumière. The essential principle of this colour photography is as follows: A sensitive film spread in the usual way over a glass plate is laid upon mercury, film downwards. Upon exposure the light rays fall through the glass upon the film, penetrate the film, and are reflected back through it from the surface of the mercury. The reflected vibrations interfere with the direct waves, so that at intervals the vibrations are neutralized, and at intermediate points they are intensified. At the former levels there will evidently be no photographic effect, while at the latter there will be a maximum. On developing, therefore, the part of the film acted upon by light of any colour, it is found to be, as it were, *stratified*, the strata being at a distance from each other equal to half the wave-length of the light in question; consequently when viewed by reflected light, the same colour is produced by interference.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

SIR,—Will you kindly inform me what part of our planet the Leonids are likely to strike on the 14th November, 1899? Will England be a good vantage ground for seeing them? and will there be a moon?

I am, yours faithfully,

Litcham, Norfolk. A. COLLISON.

[The rich part of the Leonid stream of meteors must be several hundred thousand miles in diameter, for in 1833 and 1866 the glorious display of meteors lasted for many hours. Since the earth in its orbital motion around the sun only takes about seven minutes to traverse a space equal to its own diameter, it follows that on the above occasions the earth must have been entirely immersed in the rich part of the Leonid stream, and that all parts of the earth's atmosphere on the hemisphere turned towards the Leonid radiant must have been peppered by meteoric particles; the central portions of the hemisphere, no doubt, receiving a greater share of bombardment, area for area, than the regions near to the limb. The Leonid radiant is situated at R.A. 150°, and N. Dec. 23°. The longitude of the part of the earth's northern hemisphere which will meet the greatest number of meteors will depend upon the exact time at which the earth passes through the thickest region of the swarm. The striking character of the display will, no doubt, be diminished by the light of the moon, which will be full on the 18th November, 1899. Those who wish to avoid the chances of November fog and cloud during the display would, no doubt, do well to go to Algeria or Egypt, where the radiant will pass near the zenith.—A. C. RANYARD.

VISIBILITY OF THE DARK LIMB OF VENUS.

To the Editor of KNOWLEDGE.

SIR,—In connection with the letter by M. Rudaux, in this month's KNOWLEDGE, I should like to be permitted to reiterate what I have on several occasions previously stated, both orally and in print, viz., that whenever Venus has been favourably situated, in or near her inferior conjunction, I have never failed to detect her unilluminated limb—in fact, that it has been so very visible as to have been at once perceived by totally inexperienced observers to whom I have been showing the planet.

But there has been no doubt whatever as to its appearing distinctly darker than the surrounding sky, and my own idea has always been that this had its origin (1) in the fact that it is the refraction of the sun's rays through the atmosphere of the planet, which, as it were, gives a very delicate bright fringe or seeming background to it; and (2) gives thus a complete disc, *very* slightly darker than the sky on which it is projected, as an effect of contrast to the brilliant hair-like illuminated crescent which partly surrounds it.

I do not believe in the unilluminated part of Venus being ever really seen as brighter than the sky, save as a purely optical illusion. I have myself, on several occasions, been able apparently to trace her entire outline thus, in the twilight; the dark portion presenting substantially the appearance of the lumière cendrée, or "old moon in the new moon's arms," with which everyone, astronomer or not, is so familiar. But on occulting the bright limb of the planet by suitable means, the pseudo-dark limb has absolutely vanished; showing conclusively, to my mind, that it had its origin somehow or somewhere in the eyepiece.

Yours faithfully,

Forest Lodge, Maresfield, Uckfield, WILLIAM NOBLE.
May 9th, 1894.

COMET I. 1894 (DENNING).—PERIODICAL COMETS.

To the Editor of KNOWLEDGE.

SIR,—The very small inclination ($6\frac{1}{2}°$) computed for this comet a few days after its discovery induced the belief that it was revolving in an ellipse of short period, and this has now been realized, for M. Schulhof, in *Astronomische Nachrichten*, No. 3227, gives elliptic elements corresponding to a periodic time of 6·745 years. A more exact determination may possibly be made should additional observations be forthcoming, for it is highly probable the comet is still observable in a few of the largest telescopes.

If the computed period of six and three-quarter years is correct, it would appear that the comet is only perceptible to us once in four returns, *i.e.*, every twenty-seven years, for at other times its position is too far from the earth. In 1867, if the orbit were the same as at present, the comet might have been well seen, for the earth was nearly in the same longitude as the comet's perihelion at the time the comet was there, and so the distance separating the two bodies must have been near the minimum. This ought to occur again in February, 1921, as the comet and earth will be on the same side of the sun, and the former will be projected on much the same region of sky as during its recent apparition. It is remarkable that though the comet was favourably visible and at a considerable altitude in December, 1893, January and February, 1894, it was not discovered until the end of March. The fact is significant as proving the search for these bodies is not nearly so rigorous as it might be.

M. Schulhof expresses the belief that additional periodical comets await discovery, and that a promising field for the search will be in that region of the sky opposite to the sun. The experience of recent years fully bears out the opinion of the eminent authority named, for the number of short-period comets added to the list is quite surprising:—

Name.	Perihelion Passage.	Periodic Time. Years.	Perihelion Distance.
1889 V. Brooks	1889, Sep. 30	7·073	1·95023
1889 VI. Swift	1889, Nov. 29	8·534	1·35367
1890 VII. Spitaler	1890, Oct. 26	6·378	1·81791
1892 III. Holmes	1892, June 13	6·909	2·13940
1892 V. Barnard	1892, Dec. 11	6·309	1·42911
1894 I. Denning	1894, Feb. 9	6·745	1·21

It will be noted that the perihelion distance of each of these bodies lies considerably outside the earth's orbit. It follows, therefore, that on reaching perihelion at a time when the earth is on the same side of the sun, they are very favourably visible during a considerable part, if not the whole, of the night. An encouraging line of observation is thus indicated to those interested in this branch, for careful sweeping amongst the zodiacal constellations may certainly be expected to reveal further periodical comets belonging to Jupiter's already numerous family.

Bristol, May 22nd, 1894. W. F. Denning.

To the Editor of Knowledge.

Dear Sir,—Prof. Barnard, in his article on "Magnifying Powers," refers to the fact that Saturn will bear the application of higher powers than Jupiter as a "singular peculiarity." I gave what appears to me to be the correct explanation of this matter in the *Journal of the Liverpool Astronomical Society* for February, 1886.

The focal image of any object of sensible diameter very much resembles the beautiful photographic reproductions which you give us in Knowledge. It is a stippled image, being made up of minute discs; but it differs from the photographs, in that in the focal image the bright points are so close in proportion to their diameter as to overlap. It is exactly as if the image were made up of closely set stars, which with sufficient power exhibit a spurious disc and rings. Any power that raises a disc upon a star will also raise a disc upon every point of a bright object, and this will soften the outlines and detail; but as a star disc is not a uniformly luminous patch, but is brightest in the centre, fading gradually to the first dark interference ring, it follows that with loss of brilliancy less of the spurious disc is intense enough to impress the retina, and a less brilliant star apparently gives a smaller disc. As the planets are less bright than stars, the spurious discs of which their outlines and details consist are smaller, and the less brilliant of two planets will be built up of the smaller discs, or finer stippling, and will stand a higher power before the softening effect which results is manifest. Saturn is less bright than Jupiter, therefore it should theoretically bear a higher power, as it is found to do in practice. Jupiter sends us much more light than a star, but that is because of his larger apparent diameter. His surface brightness is, however, much less than would be derived from an equal area of bright stars, but area for area he is much brighter than Saturn. This, I think, explains why Saturn bears more magnifying than Jupiter.

Yours faithfully,

Edwin Holmes.

[If Mr. Holmes is correct, the definition of the details visible upon Jupiter's surface should be improved by the judicious use of a dark wedge.—A. C. Ranyard.]

A BLACK AURORA.

To the Editor of Knowledge.

Sir,—In connection with your remarks on this phenomenon in the April issue of Knowledge, I ought perhaps to mention that the haze or cloud-haze in question seemed pretty high up, and appeared to form rapidly in the clear sky before the aurora was seen, as, indeed, often happens. You are probably right in supposing the black rays to be intervals between luminous streamers. I could see no luminous beams, but they might have been feeble or even above the layer of illuminated haze, which was apparently thin. Yours, J. Munro.

To the Editor of Knowledge.

Blackheath.

Dear Sir,—It may interest your readers to know that a very large and brilliant meteor was observed here on Sunday evening, the 22nd April, at 7.35 p.m., travelling almost due south. The nucleus was extremely bright, and appeared to scintillate, throwing off small jets of flame, which would, I presume, indicate that it was in a state of semi-explosive combustion. No stars being visible at the time—it being still daylight—I cannot say exactly through what constellations it passed, but probably a line drawn from the Great Bear to Leo Major would indicate its path. It burst silently at about the latter point.

Yours faithfully,

F. Montague James.

THE QUEEN BEE.

To the Editor of Knowledge.

Sir,—In reading the interesting paper on "Stinging Insects" in last month's Knowledge, I was much surprised to find the queen of the hive bees (*Apis mellifica*) referred to as being "the mother as well as the ruler of the hive." The latter part of this statement is, I think, quite erroneous; the mother bee can in no sense be called a ruler. She is, during the breeding season, an object of great regard and attention on the part of the workers, and this, together with her long, graceful form—quite unlike that of the little worker or the burly drone—may perhaps have given rise to this poetic fiction. She moves over the combs attended by a retinue of working bees, who offer her food from time to time as she is engaged in depositing her eggs in the cells prepared for their reception. The sole function of the queen is to lay eggs, which, as soon as deposited, are taken charge of by the workers, and are attended to by them through the various stages of development. If the queen, through an accident or old age, ceases to be prolific, she is cast out without mercy, and the workers raise another queen.

The whole of the affairs of the hive are regulated by the worker bees—some being attendant on the queen, some acting as nurse bees to the young brood, some gathering pollen, some building new comb, others gathering propolis for sealing all the chinks and crannies of the hive, some guarding the entrance to the hive against the predatory attacks of stocks in less flourishing circumstances, whilst others (and by far the greatest number) are gathering honey for the benefit of the whole community.

But though all this is done without confusion, and in the utmost order and harmony, there is, as far as I am aware, no evidence of one having more authority than another. A beehive is almost an ideal commune, where the daily and nightly labours are distributed and transacted with the most beautiful regularity and precision, each doing its own portion with a restless, untiring zeal which is marvellous.

But by what mysterious means of inter-communication, or by what strange instinct all this wonderful work is arranged and carried out—much of it in the darkness of the hive—so rapidly, with unerring precision, and with the most perfect harmony, who can tell?

Yours truly,

Lancaster, April 16th, 1894. J. T. Denham.

[No doubt the queen's chief function is the laying of eggs, and, in fact, this was the point intended to be emphasized in the passage in question. But as she is evidently the central figure in the hive, the prosperity of which depends upon her productiveness, and as her presence seems to be necessary for the orderly correlation of the various duties of the workers, it would appear to be somewhat speculative and hazardous to deny her any sort of regulative influence, such as is implied by the generally used term "queen." But a moment's consideration must satisfy anyone that comparisons between the beehive community and human communities, as they ordinarily exist, or as Mr. Denham supposes that they might exist, are probably equally far from the truth.—E. A. BUTLER.]

THE VENOM OF THE COBRA.

By C. A. MITCHELL, B.A.Oxon.

AMONG the most potent causes of death in India must be reckoned the bite of the cobra-di-capello (*Naja tripudians*), the more so as the reputed native remedies, natural and artificial, all fail as antidotes to the venom when once introduced into the system.

Experiments made by various chemists have determined the chemical nature of the poison, though, owing to the difficulty and danger of procuring sufficient for the purpose, there are few quantitative results published.

To procure the poison the reptile, which is firmly held by a native snake-catcher or strapped down by the neck, is made to strike repeatedly at a large leaf, on which the venom from the fangs collects.

As first obtained it is a frothy liquid, varying in colour from pale amber to yellow, and according to Dr. Wall occasionally colourless. Its specific gravity as compared with water is 1·058. It may be kept in a stoppered bottle for some months without material change, but eventually decomposes, giving off carbonic acid gas, and losing its toxic properties. Bacteria are found in abundance in the fresh liquid venom, as well as particles of epithelial matter, the latter being more noticeable after the liquid has been kept for a short time. The bacteria are derived from the saliva of the snake, and have been proved to add no additional virulence to the poison. When allowed to dry in the air it leaves a yellowish film, which breaks up into yellow granules of crystalline appearance, resembling particles of gum-arabic. This residue preserves all the venomous properties of the fresh poison unchanged for years, as has been proved by experiments made on animals with venom that had been kept for over twenty years. Solution in glycerine is also found to be effective in preserving the toxic properties. The yellow granules are said to possess a sharp acrid smell, though this was not noticeable in some which the writer examined, which had been kept for several years. On heating this old sample in a platinum basin it swelled up into a coke-like mass, giving off ammoniacal vapours, and on ignition left a slight ash in which sodium chloride was detected. The ash amounted to 1·5 per cent., calculated on the weight of the dried poison.

It has often been asserted that snake-venom contains an animal alkaloid similar to the ptomaines found in putrefied animal matter, but this view is not supported by the majority of chemists. Though in some cases precipitates may be obtained with the ordinary test reagents, they are not distinctly crystalline as in the case of the alkaloids.

There is a class of complex substances containing a large percentage of nitrogen, and found chiefly in the animal world, to which the name of *proteids* or *albuminoid* bodies is given. Egg albumen, which constitutes nearly the whole of the solids in the white of the egg, may be taken as a type of the proteid bodies, the average percentage composition of which is—

Oxygen, 21 to 23·5.	Carbon, 51·5 to 54·5.
Hydrogen, 7.	Sulphur, 3 to 2.
Nitrogen, 15 to 17.	Ash, variable.

When exposed to the action of acids, either mineral or such as are contained in the gastric juice, any animal albumen is converted into a substance known as *peptone*, which, while of similar composition, differs in several respects in its behaviour towards reagents, and especially in its power of diffusing through a membrane such as parchment. There is also another albuminoid substance very similar to egg albumen in its chemical composition, but differing from it in being insoluble in pure water, which is known as *globulin*.

The complex nature of cobra venom has been noticed by many investigators, but Prof. Armstrong was the first to make a quantitative analysis of a small quantity of the liquid venom, sent to him by Sir J. Fayrer. He found that it left, on evaporation, a residue amounting to 28·28 per cent. of the weight taken, and that this residue, on analysis, gave the following percentage composition, after deducting the amount of ash :—

Carbon	52·87
Hydrogen	7·05
Nitrogen	18·29
Oxygen and Sulphur ...	21·33
	99·54

This closely corresponds to the general composition of albumens, but contains more nitrogen than egg albumen.

Prof. Weir Mitchell, in a long series of experiments, proved that there were two albuminoid bodies in the venom. By means of a parchment membrane floated on running water, on which the venom was placed, he succeeded in separating the two. The coagulable proteids were left on the membrane, while the dialyzable matter passed through. The substance deposited gave all the reactions of *globulin*. In the filtrate containing what had passed through the membrane was found a substance which could be precipitated but not coagulated by absolute alcohol, which property, among others, entitled it to be placed among the peptones. He thus identified two classes of proteids :—

1. A *globulin*—Coagulable and insoluble in pure water.
2. A *peptone*—Incoagulable by *brief* boiling and soluble in pure water.

There was one noticeable peculiarity about this venom peptone: although it did not coagulate at first on boiling, yet after some time it became coagulated, being apparently converted into a globulin. In this respect it differed from ordinary peptones. Careful experiments on animals proved that it was in the peptone that the toxic principle of the venom lay. Pedler succeeded in obtaining a yellow semi-crystalline precipitate with this poisonous principle by platinic chloride, which differed, however, from that obtained with alkaloids in being less crystalline; and a similar result has been obtained by the present writer.

Owing to the similarity between the albuminoid substances in the venom and those in the blood, there is not much chance of finding an antidote which will neutralize the former without also injuring the latter. It has been found that the strength of the poison is not

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impaired by being heated to 79° C., and that death occurs as rapidly as when the unheated poison is used, but Fayrer and Wall noted that prolonged boiling completely destroyed its power. Alcohol, often spoken of as an antidote, has been shown to have absolutely no effect on the venom, and is only of use as a general stimulant to the system after a bite from a serpent. Mineral acids and the caustic alkalies neutralize it, but alum, though it delays, does not prevent death. The most active neutralizing agents yet known are potassium permanganate, ferric chloride, and iodine, especially the first; but owing to the rapidity with which the venom circulates through the system they could only be of local use, and would be of little avail once the poison were absorbed.

Taken internally, the poison is as a general rule harmless, unless there be some abrasion by which it can get into the blood. The same applies also to its action on other mucous surfaces. Fayrer mentions a case where one of his assistants accidentally got some of the venom into his eye, with no worse result than temporary inflammation. Its primary action on the respiratory system is first to cause an increase in the number of respirations and then to diminish their number. Under its influence the blood corpuscles lose their shape and become fused together and the blood becomes incoagulable. Its action on the nervous system is, comparatively speaking, unimportant, and death occurs from paralysis of the respiratory centres or from inability of the blood corpuscles to do their work. The terrible local changes which occur after death from the bite of a rattlesnake are much less noticeable in the case of the cobra.

Among the most interesting properties of the venom is its action on other snakes. Sir Joseph Fayrer on more than one occasion caused a cobra to bite its own tail, which it would do very readily, but beyond the local wound it suffered no ill consequences. Cobras were found also to be immune against the bite of other cobras, but non-venomous snakes succumbed as rapidly as warm-blooded animals. The Indian viper, the *Daboia*, whose bite is as dreaded as that of the cobra, was found to be proof against the venom, and other species of poisonous snakes more or less so, apparently according to the strength of their own venom. It would thus seem that there is in the blood of the more poisonous snakes some principle which renders the venom innocuous, and in this direction may lie the possible discovery of an antidote.

"RIB-WALKERS."

By R. LYDEKKER, B.A.Cantab.

TO say nothing of invertebrates, among which the range of diversity is still more extensive, a great difference prevails among vertebrate animals in regard to the mode of progression, although movements of this nature are nearly always effected by means of the limbs. Ordinary mammals and reptiles, for instance, either walk or run by using both pairs of limbs; but in birds and kangaroos, as well as in some of the extinct dinosaurian reptiles, progression on land is effected by the hinder pair alone, aided in some cases by the tail. Jerboas and gerbils, as well as some other rodent mammals, have likewise taken to a saltatorial mode of progression; while frogs mainly progress by means of leaps effected by the elongated hind legs. Other mammals, again, are capable of making long flying leaps by the aid of parachute-like expansions of skin along the flanks and limbs; while the bats and most birds, together with the extinct pterodactyles, alone have the fore limbs so modified as to subserve the purpose of true flight. Then we may have both pairs of limbs converted into paddle-like flippers for swimming, as in the seals among mammals, and turtles in the reptilian class; while in other cases, as in the whales and porpoises, only the fore limbs are thus modified, while the hinder pair are aborted, the tail being also adapted to act both as a kind of screw-propeller and as a rudder. In fishes, on the other hand—in which, from its vertical position, the tail is a decidedly more rudder-like organ—both pairs of limbs are used in swimming, and are aided by various paired and unpaired fins, which have no connection with the latter. Aquatic birds which float solely on the surface of the water employ their hind limbs only in swimming, although when diving many of them use their wings to a greater or less degree; but in the penguins the wings have become modified into paddles pure and simple, and are only used in diving. Frogs seem to be almost, if not quite, peculiar in using only the hind pair of limbs when swimming.

In all these instances, it will be noticed, progression is effected either entirely or mainly by one or both pairs of limbs; but there are certain groups of vertebrates in which limbs have more or less completely disappeared, and where other means of progression have consequently to be employed. Among terrestrial types, the only completely, or even practically, limbless forms are the various groups of snakes, together with certain snake-like creatures, such as the familiar blind-worm and some of the skinks, which, although ordinarily denominated snakes, are in reality nothing more than specially modified lizards, which have assumed a snake-like form.

Although these snake-like lizards creep merely by a kind of wriggling motion along the ground, the majority of real snakes progress by means of a special modification of structure, which is, perhaps, the most unique and peculiar that could well have been hit upon by creatures hampered by having to adhere to the vertebrate type of structure. Snakes in general may be in fact not inappropriately termed "rib-walkers," since their ribs are the main instruments of progression; and in thus making use of the whole length of their body and tail for this purpose they may be compared to worms and certain other symmetrically segmented invertebrates, where every joint of the body takes its share in this function. As most of us are probably aware, in mammals true ribs are comparatively few in number, and are limited to a portion of the region of the trunk. If, however, we examine the skeleton of a snake, we shall observe, in the first place, that the number of joints, or vertebræ, in the backbone is exceedingly large, and that each of these joints, from the head to a considerable distance down the tail, is provided with a pair of curved and relatively long ribs, upon the extremities of which the skeleton rests. While comparatively short in the region of the neck, these ribs gradually increase in length towards the anterior part of the trunk, and thence diminish by almost imperceptible degrees as the tail is approached. As showing the extraordinary amount of elasticity of which the vertebrate type of organization is capable without the loss of its main distinctive features, we may contrast the skeleton of a snake with that of a frog, when we shall find that whereas the one attains the maximum development in the way of ribs, the other has these structures reduced to a minimum. In fact, for all practical purposes, a frog may be described as a ribless creature; the ribs being represented by small rudimentary bones attached to the extremities of long horizontal processes standing out from the sides of the vertebræ. And it may be incidentally mentioned that in consequence of this practical absence of ribs, a frog cannot

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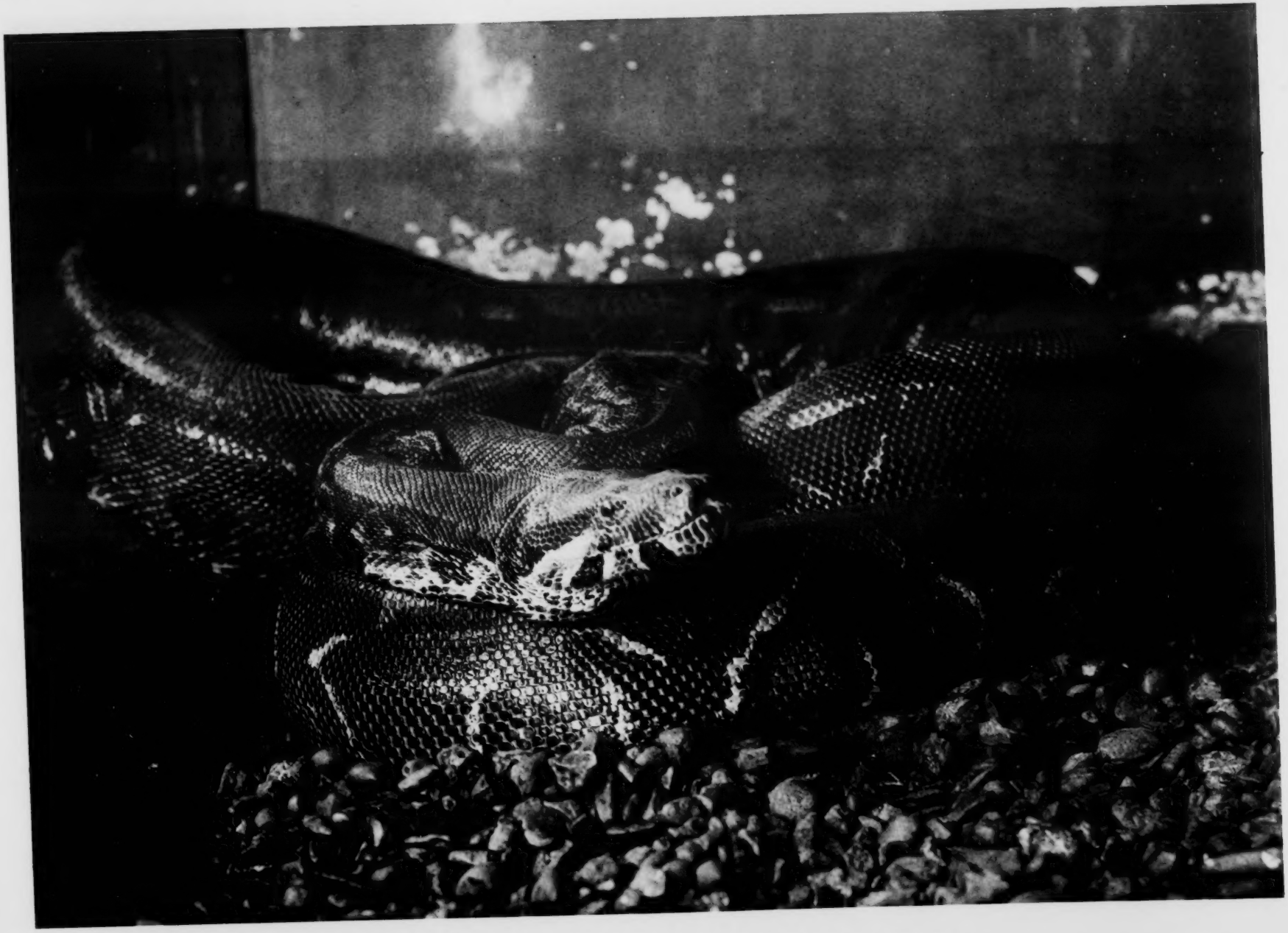

LARGE RETICULATED PYTHON FROM MALACCA *(Python reticulatus).*

Reproduced from a photograph taken inside its cage at the Zoological Gardens, Regent's Park. The forked tongue is withdrawn within the mouth, showing the notch in the upper lip through which the tongue protrudes. This Python is thirty years of age, is over twenty feet in length, and is twenty inches in circumference round its thickest part. It was presented to the Society in August, 1876, and is fed once a week with ducks and rabbits, which it kills by strangulation.

Reproduced from a photograph taken inside its cage at the Zoological Gardens, Regent's Park. The forked tongue is withdrawn within the mouth, showing [illegible] through which the tongue protrudes. This Python is thirty years of age, is over twenty feet in length, and is twenty inches in circumference round its thickest part. It was presented to the Society in August, 1876, and is fed once a week with ducks and rabbits, which it kills by strangulation.

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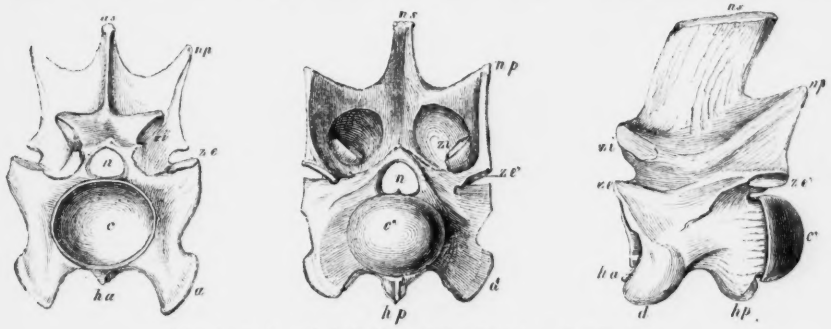
breathe in the ordinary way by expanding and contracting its chest, and therefore has to swallow air by taking in a gulp, closing the mouth, and then forcing it into the lungs.

Regarding, then, a serpent as essentially a "rib-walker," we have to see, in the first place, how this most peculiar and original mode of progression is effected; while in the latter portion of our article we must point out the chief family groups into which serpents are divided, and likewise



Front, Back, and Left Side of the Vertebra of a Snake.

indicate why naturalists will run contrary to popular opinion in telling us that a blind-worm is a lizard and not a snake.

In a creature that has taken to a mode of progression so peculiar as is that of a snake, the first essential is a combination of strength with extreme flexibility in the backbone, and this is attained by the development of an extremely complicated system of articulation between its constituent vertebræ. In ordinary terrestrial vertebrates the vertebræ are connected with one another by two main articulations. In the first place, the centrum or body of every vertebra has a surface at each end for articulation with the adjacent members of the series, and when firmness and strength is the main object, as in the back of mammals, these two surfaces are nearly flat; when, however, greater mobility is required, as in the neck of the more specialized hoofed mammals, this is effected by means of a ball-and-socket joint; and in the snakes this ball-and-socket arrangement extends throughout the whole series, the cup (*c* of the foregoing figure) being in front, and the ball (*c'*) behind. In addition to this articulation, vertebræ are ordinarily connected by what are termed zygapophyses, or flattened facets attached to the arch or upper half of the structure—the anterior zygapophysis (*ze*) always looking upwards, while the hinder one (*ze'*) faces downwards. For all ordinary purposes these two systems of articulation are amply sufficient; but snakes required something more, and they have accordingly developed an additional pair. In the upper part of the middle figure of our illustration there will be seen a pair of deep pits (*zi*) on the hinder aspect of the arch of the vertebra, which have received the somewhat long name of zygantra, and show a flattened articular facet directed upwards and inwards on the lower half of their outer sides. Into each of these pits is received a somewhat wedge-shaped projection from the front of the arch of the adjacent vertebra (marked *zi* in the left-hand figure of our illustration), and termed the zygosphene, the flattened articular facet of which looks downwards and outwards. Such a triple system of articulation produces, of course, extreme flexibility of the backbone, without any danger of dislocation of the joints, as any of our readers may ascertain for themselves by handling the articulated skeleton of a snake. It might be thought that this remarkable system of articulation was peculiar to snakes, and if it were so we should be able to define that group of animals much more neatly and definitely than we are at present able to do. Unfortunately, however, for the systematist, the iguanas among living lizards, together with certain members of some extinct groups of reptiles, have precisely similar vertebral articulations, which are due to that tiresome parallelism in development alluded to so frequently in some of our earlier articles. We believe, however, we are right in saying that none of the snake-like lizards possess these additional articulations to the vertebræ.

Before leaving the subject of the backbone, it must be added that the ribs, which are single-headed, are attached to a facet (*d*) on the lower part of the front end of each side of the body of the vertebra; such facets being usually situated on the body itself, although in the figured specimen, which belongs to an extinct genus, they have distinct pedicles. Although this mode of rib-connection is common to lizards and serpents, it is precisely that best adapted to afford the greatest amount of motion to "rib-walkers." It may be added that in all snakes the breast-bone and bones of the shoulder, like those of the fore limb, are completely wanting; while there are, at most, only vestiges of those of the pelvis and hind limbs.

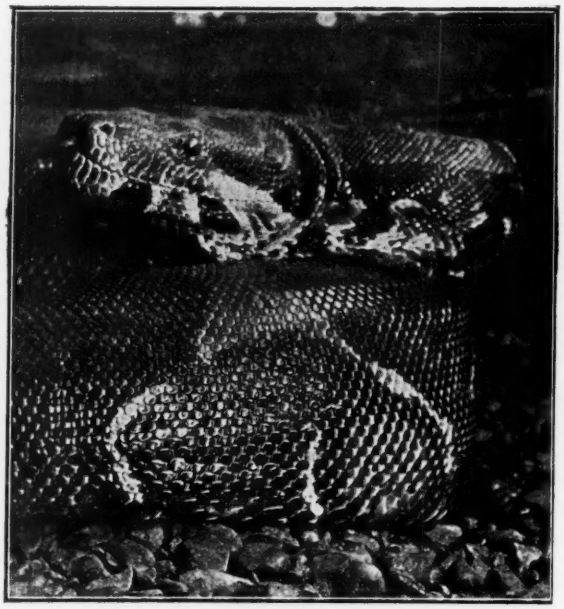
Dismissing the interesting subject of the skeleton with these few remarks, we come to the consideration of how the reptiles under consideration walk. Now, if we examine any ordinary snake, we shall find that the under surface is covered with a series of oblong transverse shields, overlapping one another by their hinder edges, and in the body extending right across the lower surface, although in the tail they very frequently form a double series. Each of these shields corresponds to a pair of ribs, and all are of the utmost importance in terrestrial locomotion. On this point Dr. Günther writes that when any portion of the body of a snake "has found some projection on the ground which affords it a point of support, the ribs, alternately of one and the other side, are drawn more closely together, thereby producing alternate bends of the body on the corresponding side. The hinder portion of the body being drawn after, some part of it finds another support on the rough ground or a projection; and the anterior bends being stretched in a straight line, the front part of the body is propelled in consequence. During this peculiar kind of locomotion the numerous hard shields of the belly are of great advantage, as, by means of their free edges, they are enabled to catch the smallest projections on the ground, which may be used as points of support." It follows from this that on a perfectly smooth surface, like a sheet of glass, a snake is utterly unable to move. It may be added that these reptiles can only progress by undulating the body in a horizontal direction; and that the pictures sometimes seen of snakes with the body thrown into folds in a vertical plane are pure evolutions of the artistic imagination.

That the large inferior shields of snakes have been specially developed for the needs of this peculiar mode of progression, there can be no doubt; but, although they are absent in the snake-like lizards, they are by no means characteristic of the group as a whole. A further

specialization seems, indeed, to have taken place in certain members of the group, which have adopted a mode of life in which these organs would be useless. An excellent instance of this is afforded by the venomous sea-snakes of the warmer oceans, the typical members of which are purely pelagic in their habits, and have the under surface of the body covered either with small scales, or retaining mere vestiges of the large shields. That this departure from the ordinary type is a specialized character is, fortunately, demonstrated by one genus of these serpents (*Platurus*), the members of which are partly terrestrial in their habits, and consequently retain the large inferior shields. All the burrowing blind snakes, so widely distributed over the warmer regions of the globe, together with members of several groups which have taken to a purely arboreal life, have likewise lost the large inferior shields, as being no longer useful.

In the pre-Darwinian days of natural history it was doubtless considered that snakes were created as such, and that they were always "rib-walkers." The modern naturalist, however, knows better than this, since some of the members of the group, fortunately, retain vestiges which enable him to say with confidence that serpents are the highly modified descendants of four-legged reptiles, more or less nearly akin to lizards. Among the better-known members of the group, pythons and boa-constrictors, collectively constituting the family *Boiidæ*, are those alone retaining such vestiges, which externally take the form of a pair of claw-like spurs situated on the lower surface near the junction of the body with the tail. If, moreover, we dissect such a snake, it will be found that traces of the three bones of the pelvis are imbedded among the muscles, although now of no functional importance whatever. And if such rudiments are not to be regarded as indicative of the descent of snakes from reptiles furnished with limbs, we may as well give up trying to apply philosophical reasoning in zoology.

Putting aside the little-known group of blind snakes, the pythons and boas are indeed the most primitive of all serpents, and the more typical members of the group are distinguished by their habit of destroying their prey by "constriction." All pythons and boas, it is perhaps well to observe, are non-venomous, and the family includes by far the largest representatives of the entire ophidian group. The excellent photographs with which this article is illustrated were taken by Mr. Ranyard inside the cage of the python, at the Zoological Gardens, Regent s Park. Formerly it was attempted to arrange all the other and more specialized snakes, in which traces of the hind limbs have completely vanished, into families, according as to whether they were innocuous or venomous; but modern research has shown that such divisions are purely artificial, and that the development of poison-bearing organs has originated independently in several distinct groups, thus affording another excellent example of parallelism. There is, however, one family of snakes (*Viperidæ*), including the ordinary vipers and rattle-snakes, all the members of which are venomous, and may be distinguished from the members of the other great family by the circumstance that when the jaws are opened the maxillary bones, in which are implanted the pair of long tubular poison-fangs, become erected at right angles to the hinder part, thus giving to the teeth the most powerful mode of action possible. The other great family of limbless snakes (*Colubridæ*) comprises both harmless and poisonous forms, and is distinguished from the viper family by the absence of the power of erecting the maxillary bones. These snakes, which include by far the greater majority of the entire group, are remarkable not only for the extraordinary adaptability to different modes of life they display —some of them being terrestrial, others arboreal, others fluviatile, and others marine—but still more for the circumstance that members belonging to totally different sections of the family have become independently modified to similar modes of life, and have thus acquired an external similarity which effectually masks their structural differences. Their true relationships appear to be best revealed by the structure and arrangement of the teeth; and on this evidence they are divided into three parallel sections, each of which shows a very similar series of adaptations to particular modes of life. In the first great section, or



Side view of the Head of the Python at the Zoological Gardens. The fold beneath the head and neck is more than six inches thick.

solid-toothed colubrines, the whole of the teeth are solid and frequently subequal in size; and it is, therefore, evident that all the members of the group (in which is included the common English ringed-snake), are perfectly harmless. In a second section, which may be termed the hind-fanged colubrines, one or more of the hinder upper teeth are enlarged and grooved; and it would appear that the majority of the group are more or less poisonous. Among these snakes are the well-known arboreal whip-snakes (*Dryophis*) and sand-snakes (*Psammophis*). The front-fanged colubrines, which are far more deadly, differ from the last in having the front teeth in the maxillary bones enlarged and either grooved or tubular for the purpose of carrying the venom from the poison-gland to the wound. This section includes the dreaded Indian crait, as well as the cobras of Asia and Africa, both of which are to the full as deadly as any of the vipers; while the sea-snakes also belong to it. That the front-fanged and hind-fanged colubrines have acquired their venomous properties entirely independent of one another is perfectly evident from the different position of the teeth modified for this purpose; and the wide structural difference between the vipers and colubrines shows that the former have no sort of connection with either of the sections of the latter. We have, accordingly, clear evidence of the development of poison-glands and fangs in three totally independent

instances, which is perhaps the most striking example of parallelism that can be adduced. The extraordinary feature, to our mind, in the case is the eventual general similarity of structure which has been attained in the three instances—a similarity which appears difficult of explanation on the ordinary theories of evolution.

Coming to the last section of our subject, we have to indicate how snakes may be distinguished from lizards, and to add a few words as to the relations of the two groups. We have seen that neither the structure of the vertebræ nor the presence or absence of shields on the lower surface of the body will suffice to distinguish between the two groups; and it may be added that neither will the forked and retractile tongues of the snakes serve our purpose, since a similar structure is possessed by certain lizards. It has, however, been already mentioned that none of the snake-like limbless lizards have the additional articular surfaces characterizing the vertebræ of snakes; and to this it may be added that none of the former have the tongue capable of being retracted into a sheath at its base, in the manner distinctive of snakes. An infallible, though not very important, point of distinction between snakes and lizards is to be found in the circumstance that whereas in the latter the two branches of the lower jaw are always united by suture, in the former the bond of union is a ligamentous one; and there are also certain other points of distinction, into the consideration of which it will be unnecessary to enter.

The structural differences in regard to the vertebræ and tongue, coupled with the circumstance that there is more than a single group of lizards, render it pretty certain that snakes are not the final result of the modification of ordinary lizards into snake-like forms. The snake-like lizards may accordingly be regarded as a kind of bad attempt to evolve a snake, since these creatures are by no means numerous, and have not thriven and multiplied after the manner of the true snakes. Whether, indeed, snakes as such have taken origin from reptiles which would be included by zoologists among lizards is more than doubtful, although palæontological evidence is, unfortunately, very imperfect on this point. Both groups are, however, of considerable antiquity, true snakes of large size, and apparently as specialized as existing forms, dating from the London clay, while bones which have been referred to lizards occur in the Cambridge greensand. Possibly the nearest approach to the common ancestral form is a certain small lizard-like reptile from the English chalk known as *Dolichosaurus*, differing from existing lizards by the greater number of vertebræ in the neck and the more simple structure of the feet, and having snake-like vertebræ. Should this be the case, it would seem that ordinary lizards have lost the additional articulations characterizing the vertebræ of serpents.

THE WOOD-PIGEON.

By HARRY F. WITHERBY.

THE wood-pigeon (*Columba palumbus*) is the largest representative of the genus *Columba* to be found in Europe.

It occurs plentifully throughout England and Scotland, and remains in the wooded and sheltered districts all the year round, but is only a summer visitor in the more northern parts of the kingdom. In winter wood-pigeons congregate, and go about the country in flocks, which are no doubt largely augmented by numbers of birds which come over from the Continent.

The wood-pigeon is sometimes called the ring dove, on account of the white feathers which form a partial ring round its neck. It is naturally a very shy and wary bird, and it requires careful stalking to get a shot at one in the daytime; but they may be easily shot in the evening, when coming home to roost in the trees. It is sought after on account of its destructiveness to crops, as well as on account of its flesh, which is very good eating as a rule; but at the time of the year when turnip-tops form its chief food, its flesh has a disagreeable flavour.

Although a very shy bird, the ring dove may often be seen in the London parks, especially in St. James's Park, where it even breeds. In the summer months I have seen as many as ten together, feeding on the piece of grass under Lord Beaconsfield's statue in Parliament Square, opposite Westminster Abbey. Here they seem quite at home, and take no notice of the people or traffic, and although there is always a large flock of dovecot pigeons close to them, the two species keep quite separate from each other. The ring dove becomes comparatively bold in gardens, and destroys a large amount of fruit in the summer months. It is especially fond of currants, pears being also a favourite dainty; but its ordinary food consists of buds and young green leaves, beech-mast, acorns, and grains of various kinds. Wood-pigeons swallow their food whole, and as many as ten perfect acorns have been found in the crop of a single specimen. When drinking, the ring dove does not take short sips like other birds, but satisfies its thirst in one long draught as a horse would.

Its mode of alighting is very elegant. It descends with a headlong swoop until within about two feet of the ground, when suddenly it checks its rapid motion by reversing the position of its head, and spreading out wings and tail, drops gently to the ground. It is when in this position that the tail is best seen, for it is then spread out like a fan, so that every feather is visible.

Its note is very plaintive and resembles the syllables "coo, coo, coo, coo," the first two and the last being long, whilst the third is very short. The number and length of these syllables are occasionally varied. This note may be heard at all times of the day in a neighbourhood frequented by wood-pigeons, and from its plaintiveness the bird is supposed to have received the name "Queest." In some parts of the country, however, it is called the cushat, a name the derivation of which is uncertain.

The ring dove's nest is of the frailest description; it is formed for the most part of sticks, while occasionally a few roots and feathers are placed on the top of these to do duty for lining. The nest is always very flat, and is sometimes so lightly put together that the eggs or young may be seen from below. It is generally built in small trees in woods and plantations, and is thus protected from the wind. Occasionally, however, the nest may be found in more open situations, and in this case it is built more compactly and is much stronger than when placed in a sheltered spot. The nest represented in the accompanying illustration is a good example of those found in isolated trees exposed to the full force of the wind. The nest is built at a height from the ground varying from six to forty feet. When the bird has been sitting some few days, the top of the nest assumes a whitish appearance arising from a white powder in the bird's plumage.

The eggs are pure white, and two in number. Two or three broods are reared in a season, the first eggs being laid in April, or even in March, and a wood-pigeon has been found sitting on two eggs as late as September.

The young are hatched in seventeen days; they are at first covered with yellowish down, and their eyes

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are covered by a film for the first nine days. They are fed from the beaks of the parent birds with a whitish secretion, often described as milk, which is supplied from the crops of the old birds. The habit of feeding the young in this manner applies to all the pigeon family.

The flight of the wood-pigeon is extremely rapid, and when in the air it may be distinguished from others of its genus at a considerable distance by a bar of white feathers, which traverses the wing. Its feathers are very loosely attached to the skin, so that they fall out with even a slight blow. When suddenly disturbed from a bush, a wood-pigeon will often lose several feathers by its contact with twigs in getting away.

The Wood-Pigeon and Nest.

The male measures seventeen inches from the tip of the beak to the end of the tail. The female is slightly smaller, and, except in this particular, scarcely differs from her mate in general appearance. The head and back are bluish-grey, and the upper part of the neck is of the same colour, but the feathers on the sides of the neck are tipped with white, and thus form the partial ring mentioned above. The breast and under side of the neck are purple-red, while the belly and under-tail coverts are ash-grey. The tail feathers are twelve in number, and are of three shades of grey. The beak, legs, and toes are dark pink.

Young birds of the year have no white on their necks, and their whole plumage is less glossy than that of adult wood-pigeons.

THE FACE OF THE SKY FOR JUNE.

By Herbert Sadler, F.R.A.S.

WHENEVER the solar disc is examined, it will be seen to be marked with spots and faculæ. A maximum of the beautiful red star R Leonis occurs on the 1st of June.

Mercury is an evening star during the whole of the month, and, but for the prevailing twilight, would be very favourably situated for the observer. He sets on the 1st at 9h. 27m. P.M., or 1h. 23m. after the Sun, with a northern declination of 25° 16′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{83}{100}$ths of the disc being illuminated. On the 10th he sets at 10h. 4m. P.M., with a northern declination of 25° 2′, and an apparent diameter of $6\frac{1}{2}''$, $\frac{64}{100}$ths of the disc being illuminated. On the 16th he sets at 10h. 3m. P.M., or 1h. 47m. after the Sun, with a northern declination of 23° 34′, and an apparent diameter of $7\frac{1}{4}''$, just one half of the disc being illuminated. On the 21st he sets at 9h. 56m. P.M., or 1h. 39m. after the Sun, with a northern declination of 21° 54′, and an apparent diameter of $7\frac{3}{4}''$, $\frac{33}{100}$ths of the disc being illuminated. He is at his greatest eastern elongation ($25\frac{1}{4}°$) on the 23rd. On the 30th he sets at 9h. 27m. P.M., or 1h. 9m. after the Sun, with a northern declination of 18° 38′, and an apparent diameter of $9\frac{1}{3}''$, $\frac{26}{100}$ths of the disc being illuminated. During the month he passes from Taurus through Gemini into Cancer.

Venus is a morning star, but is now becoming rather an uninteresting object for the amateur. She rises on the 1st at 2h. 20m. A.M., or about an hour and a half before the Sun, with a northern declination of 9° 0′, and an apparent diameter of 17″, $\frac{65}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on February 3rd. On the 10th she rises at 2h. 4m. A.M., with a northern declination of 12° 19′, and an apparent diameter of 16·0″, $\frac{69}{100}$ths of the disc being illuminated. On the 20th she rises at 1h. 50m. A.M., or nearly two hours before the Sun, with a northern declination of 15° 43′, and an apparent diameter of 15·0″, $\frac{73}{100}$ths of the disc being illuminated. On the 30th she rises at 1h. 41m. A.M., or 2h. 6m. before the Sun, with a northern declination of 13° 37′, and an apparent diameter of 14·0″, $\frac{76}{100}$ths of the disc being illuminated, and the brightness of the planet being about equal to what it was on February 5th. During June Venus passes through Aries into Taurus.

Mars, Jupiter, and Neptune are, for the purposes of the amateur observer, invisible.

Saturn is an evening star, and is well placed for observation. He rises on the 1st at 2h. 54m. P.M., with a southern declination of 4° 52′, and an apparent equatorial diameter of 18·0″ (the major axis of the ring system being 41″ in diameter, and the minor $8\frac{1}{4}''$). On the 15th he rises at 1h. 54m. P.M., with a southern declination of 4° 49′, and an apparent equatorial diameter of $17\frac{1}{2}''$ (the major axis of the ring system being $40\frac{1}{2}''$ in diameter, and the minor 8·0″). On the 30th he rises at 1h. P.M., with a southern declination of 4° 54′, and an apparent equatorial diameter of $17\frac{1}{4}''$ (the major axis of the ring system being $39\frac{1}{2}''$ in diameter, and the minor $7\frac{3}{4}''$). Titan is at his greatest eastern elongation on the 16th, and Iapetus is in superior conjunction on the 6th, and at his greatest eastern elongation on the evening of the 26th. During the month Saturn is almost stationary in Virgo.

Uranus is also an evening star, and but for his southern declination would be well placed for the observer. He rises on the 1st at 5h. 10m. P.M., with a southern declination of 15° 7′, and an apparent diameter of 3·8″. On the 30th he rises at 3h. 15m. P.M., with a southern declination of 14° 54′. During June Uranus pursues a short retrograde path to the N.W. of α^1 α^2 Libræ, being about 1′ north of a $10\frac{1}{2}$ magnitude star on the 22nd.

There are no well marked showers of shooting stars in June.

The Moon is new at 10h. 56m. P.M. on the 3rd; enters her first quarter at 1h. 14m. P.M. on the 10th; is full at 7h. 6m. A.M. on the 18th; and enters her last quarter at 10h. 3m. A.M. on the 26th. She is in perigee at 6h. A.M. on the 5th (distance from the earth 223,620 miles), and in apogee at noon on the 20th (distance from the earth 252,270 miles). At 9h. 0m. P.M. on the 12th the 6th magnitude star 58 Virginis will disappear at an angle of 187° from the north point, and reappear at 9h. 37m. P.M. at an angle of 246°. At 0h. 41m. A.M. on the 14th the 6th magnitude star B.A.C. 4700 will make a near approach to the northern limb at an angle of 23°, distance about 2′. At 11h. 20m. P.M. on the 14th the 6th magnitude star B.A.C. 4923 will disappear at an angle of 175°, and reappear at 11h. 57m. P.M. at an angle of 232°. At 9h. 2m. P.M. on the 15th the 6th magnitude star B.A.C. 5197 will disappear at an angle of 108°, and reappear at 10h. 23m. P.M. at an angle of 300°. At 10h. 46m. P.M. on the 19th the 6th magnitude star B.A.C. 6628 will disappear at an angle of 80°, and reappear at 0h. 8m. A.M. on the 20th at an angle of 267°.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem No. 17.

Key-move—1. R to Q3.

If 1. . . . K × P, 2. Q to Kt3ch.
1. . . . P to B4, 2. Q to Kt3.
1. . . . K × R, etc. 2. Q to Q5ch.
Triple after 1. . . . P × P by 2. R to K3ch, or 2. Q × RPch, or Q to Kt3.
Dual after 1. . . . K to B4 by 2. Kt × Pch, or 2. P to Kt3.

Solution of Problem No. 18.

Key-move—1. B to R2.

If 1. . . . K × R, 2. Q to B4ch.
1. . . . Kt × R, 2. B to Q5ch.
1. . . . Kt (Q8) moves, 2. R to K3 (× Kt) ch.
1. . . . B moves, etc., 2. R to Q4ch.
Dual after 1. . . . Kt to R5 by 2. R to Q4ch or 2. B to Q5ch.

Solutions of Problem No. 19.

Two Solutions, viz.—1. R to R5 (Author's), and 1. P to K6.

Correct Solutions received from the following:—

Fifteen Points.—Guy.

Fourteen Points.—Semper, B. G. Laws.

Twelve Points.—A Norseman.

Eleven Points.—Chat, Kt. J.

Nine Points.—E. W. Brook, L. Bourne, A. C. Challenger.

Eight Points.—J. H. Christie.

No. 18 is correctly solved by H. S. Brandreth.

Mr. De Morgan's Conditional Problem is solved by Chat, W. Willby, E. W. Brook, B. G. Laws, A Norseman, and Guy. Strangely enough, it is pronounced unsolvable by Semper.

The solution is 1. Q to Q2, Q × B; 2. P to B4ch, R to Kt5; 3. Q × Q mate.

It should be noted that according to the supplementary rule, published in the December number of Knowledge, the triple continuation in No. 17 does not score more than an ordinary dual.

J. H. Christie.—In No. 17, after 1. . . . K × P, 2. Q to Q5, P to B4 is a good defence. One point was accordingly deducted from your score.

A Norseman.—Your three letters and postcard containing solutions were duly received. In No. 17 there is no dual after 1. . . . P to Q3 (*sic*), but as the claim was unintelligible, nothing has been deducted for it.

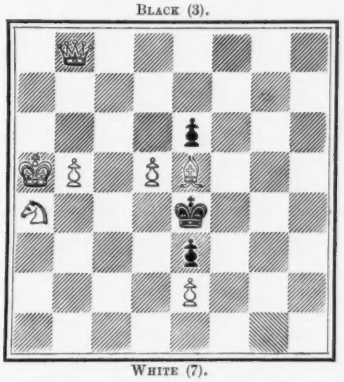
Guy.—You are quite right to inquire how we knew that the "Circle" was by a well-known composer. The sealed envelope has not been opened, but the problem was delivered to us by the hand of the composer in question, whose handwriting happens to be familiar to us. We assumed accordingly that it was his own composition.

A. C. Challenger.—Many thanks for the problems. Both are excellent and will appear next month.

PROBLEMS.

By Mrs. W. J. Baird.

Black (3).

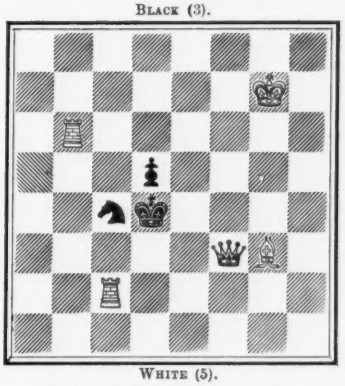


White (7).

White mates in three moves.

By C. D. Locock.

Black (3).



White (5).

White mates in two moves.

[After the hard work of the solution tourney, it is hoped that the foregoing comparatively simple positions will come as a relief.]

"KNOWLEDGE" SOLUTION TOURNEY.

FINAL SCORE.

Guy	91	J. H. Christie ...	60
Semper	90	A Norseman ...	60
B. G. Laws	88	E. W. Brook ...	53
A. C. Challenger ...	79	H. Holmes	50
Kt. J.	69	L. Bourne	46
Chat	67		

The first prize is accordingly taken by "Guy" (F. H. Guest, Birmingham, and the second by "Semper" (T. Guest, Birmingham), who is only one point behind. Mr. Laws had the misfortune to miss one of the solutions of No. 15, or would have tied for first place. The remainder, some of whom did not trouble themselves much about the search for duals and second solutions, have all proved themselves capable solvers in nearly every instance. It is noticeable that even the winner missed five duals in the fifteen sound problems. The highest possible score was 96. The award will, as usual, remain open for one month.

"KNOWLEDGE" PROBLEM TOURNEY.

Of the nineteen positions published, four—viz., Nos. 6, 7, 15, and 19—having more than one key, are ineligible for prizes. The remainder have to be voted on by the solvers. Strictly speaking, the only solvers entitled to vote by the rules are seven in number, viz., Guy, Semper, B. G. Laws, A. C. Challenger, Kt. J., Chat, and J. H. Christie. We hope, however, that no objection will be raised to the admission of the following under the conditions named, viz. :—

A Norseman—Votes to be accompanied by full correct solution (including *all* the mates) of No. 11, the problem in which he failed.

E. W. Brook—*Full* solutions of Nos. 1 and 2, not received.

A. R. and *H. Holmes*—*Full* solutions of Nos. 17 and 18, not received.

These additions, including the Chess Editor, will bring the number of the jury up to twelve. The solvers named are requested, therefore, to send in, *on or before June 15th*, a list in order of merit of the *seven* problems which they consider best. Brackets may be used *sparingly* if desired. Any voting paper which names any one or more of the unsound problems referred to above, *or which does not name seven problems, neither more nor less*, will be disqualified. A problem placed first by any voter will receive nine marks, a problem placed second eight marks, and so on down to the seventh, which will receive three marks. A problem placed first will thus secure three times as many marks as a problem placed seventh. As soon as all the voting papers are received the marks will be added up, and the *six* problems which obtain most marks (or perhaps seven if the numbers are close) will receive the consideration of the final judge, whose name will be announced shortly.

N.B.—In order to avoid mistakes, voters are requested to name the problems by the *motto* rather than by the number.

In order not to be influenced by the votes of others, the Chess Editor binds himself to complete his own voting paper before opening any others.

It is hoped that any solvers who may happen to be competitors in the problem tourney will not be deterred by any feeling of modesty from giving their own problems as many marks as they consider they deserve.

CHESS INTELLIGENCE.

The portion of the championship match played at New York resulted in favour of Mr. Lasker, who won four games to Mr. Steinitz's two. The Philadelphia games were even more disastrous to Mr. Steinitz, resulting as they did in three losses, the play of the loser being much below his usual standard. The concluding series took place at Montreal, and here, in a friendly city, Mr. Steinitz made an excellent start. The first game was drawn, and Mr. Steinitz won the next two in fine style. In the next two Mr. Lasker had his revenge, the score on May 20th being Lasker nine, Steinitz four, drawn four. Mr. Lasker accordingly only needs to win one game to win the match, and though his opponent is always at his best in an uphill contest, the result must now be regarded as a certainty.

A team of Manchester players has been visiting the Metropolis and playing matches with the leading London clubs. They lost by a narrow margin to the St. George's and Metropolitan Chess Clubs. Matches with the British Chess Club and the City of London will complete their programme. The composition of the team is by no means representative of the full strength of the northern club.

LATE NEWS.—Mr. Steinitz won the eighteenth game.

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